HIP-POCKET MANUAL

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C-9925 P/N 1842401

REPAIR TEST SET

Section I: A Troubleshooting Guide
Elements of Fault Locating and Transmission Testing

Section II: Operator's Manual

Section III: Access System

COMMUNICATIONS TECHNOLOGY CORPORATION

DALLAS, TEXAS • TORONTO, CANADA

C-9925

Elements of Fault Locating and Transmission Testing
— A Troubleshooting Guide —

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FORMAT

This manual contains two main sections:

I. Elements of Fault Locating and Transmission Testing — A Troubleshooting Guide

In Section I, the basic theory of fault analysis and location is discussed, as well as the principles of proper transmission quality. This section will familiarize the technician with the types of troubles which occur on a cable pair, and the principals and parameters of acceptable signal transmission on the loop. The text is cross-referenced with the Operator's Manual to show the actual test routine called for to perform analysis.

II. C-9925 RTS Operator's Manual

Section II is a complete and detailed Operator's Manual for the RTS. It discusses both the automatic and manual test routines and shows the testing sequences in a flow-chart layout, with the actual LCD readouts displayed and explained.

III. C-9925A Access System

Section III describes the new features and functions that the Repair Test Set craft access model provides.

GENERAL

The Communications Technology C-9925 Repair Test Set (RTS) is a microprocessor based, menu-driven, state-of-the-art testing computer, designed for today's Telco field technician. With a simple 3-cord hookup to tip, ring, and ground, the unit will quickly and accurately analyze all conditions on a subscriber's line. When a fault is detected, the RTS will identify the type of trouble and display its location in feet from the set. After all troubles are corrected, the unit will analyze the quality of service on the loop by performing a series of Loop Transmission Measurements (LTM), and displaying its findings as acceptable or unacceptable.

The RTS replaces most analog test sets used in the field today. With a single attachment and logical sequence of tests, all service-affecting characteristics of the test pair are analyzed. If the problem is in the CPE and billing is required, the RTS can be used to print out testing results for the subscriber. The technician can complete daily specific tasks with an ease and confidence never before available. Management can rely on the accuracy and speed of the tests, and the customer will receive a higher quality of service.

Since deregulation, the Telco Customer has had a choice of station equipment and long distance carrier. When a subscriber complains of service interruption, the Telco providing service will determine what and where the problem is and fix any cable pair or Central Office troubles. If the problem is proved to be in the station equipment beyond the protector, or in the long distance carrier, the customer is informed and can be provided with a printed copy of the test results from the RTS. The individual Telco providing service has all responsibilities for service restoration in cable plant from the protector to the Central Office.

Beginning with the physical makeup of cable, this manual will show the electrical characteristics of transmission and will define the parameters for acceptable subscriber service.

CHARACTERISTICS OF CABLE

When cable is ordered from the manufacturer, it is ordered to specifications of sheath, insulation, gauge, pair count, etc., to comply with the engineering design for a specific transmission usage.

The uses may range from underground manhole runs for trunking cables between Central Offices, or from the C.O. to control points for distribution into several areas. These large diameter cables are normally pulp insulated. Special cables are ordered for carrier circuits. Standard aircore and filled PIC cables are used for exchange circuits. Small gauge cable such as 26 or 24 gauge is normally used close to the Central Office because it is less expensive and there are more pairs available per a given cable diameter. As the distance from the Central Office increases, larger diameter conductors are required to compensate for current flow resistance. Commonly used conductors in telephone cables are 26, 24, 22, and 19 gauge.

Before the cable is shipped, factory testing is done to assure that the cable meets required specifications. The cable is tested for shorts, crosses, and opens. Insulation and conductor resistance are tested, as well as resistance unbalance between conductors, inductance, conductance, mutual capacitance, and capacitance deviations between pairs in the cable. Capacitance unbalance pair-to-pair and to ground is tested for acceptable noise rejection. When a cable passes these and other miscellaneous tests, it is shipped to the Telco customer.

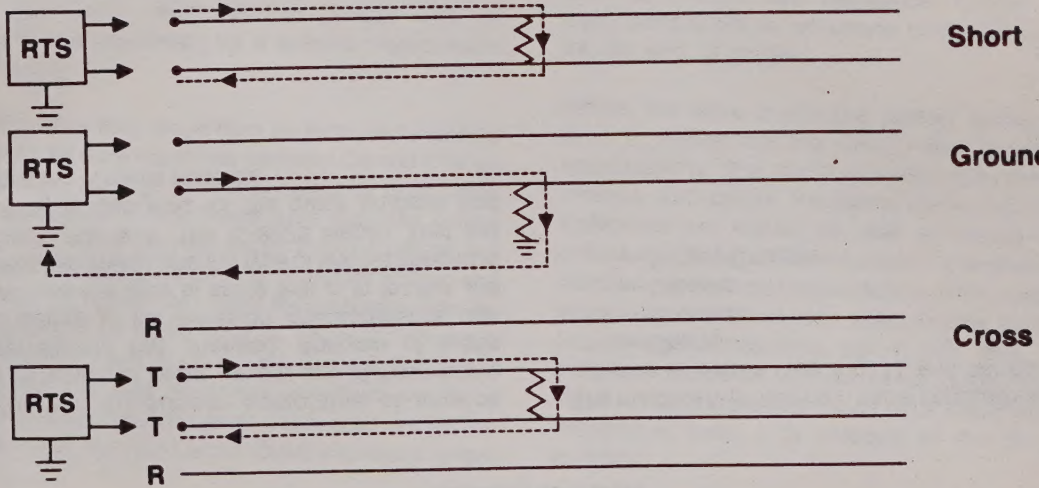
RESISTANCE FAULTS

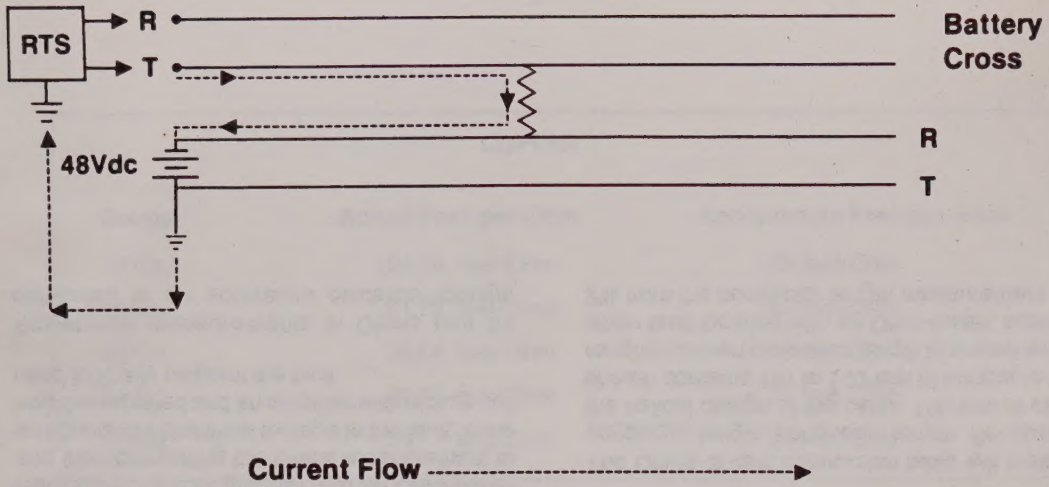
When a subscriber complains of service interruption or noise, usually one of these cable parameters has changed. Analysis of subtle changes in transmission characteristics can indicate the type of cable that is in trouble, the possible cause, and the type of test set needed to locate the fault. The C-9925 Repair Test Set (RTS) is designed for the quick analysis and location of cable troubles.

The majority of problems in cable conductors are resistive in nature (see Fig. 1), and consist of:

- — Shorts
- — Grounds
- — Crosses
- — Battery Crosses

Figure 1
Resistive Faults




RTS
R
T
Battery
Cross
48Vdc
R
T
Current Flow

Historically, resistive fault locating was done using either a Wheatstone Bridge to pinpoint high resistance faults (a time-consuming procedure), or by measuring the resistance of a solid trouble (zero Ohm short or ground) with an Ohm-meter and then converting the Ohms measurement to an equivalent electrical footage to the fault. Tone was then applied and an amplifier with pickup coil used to finally pinpoint the fault.

Resistance measurements in Ohms can be converted to an equivalent electrical footage depending on the gauge and temperature of a conductor. The resistance of the common copper gauges at 68 degrees Fahrenheit is listed below.

The Ohms-to-feet conversion table will indicate conductor length, not sheath length. Because of the helical design of the cable, 100 feet of cable sheath contains 101 to 103 feet of conductor. To roughly convert conductor length to sheath length when fault locating with an Ohm-meter, subtract 2% from the conductor length measurement.

COPPER		
Gauge	**Actual Feet-per-Ohm**	**Approximate Feet-per-Ohm**
19 Ga.	124.24 feet/Ohm	125 feet/Ohm
22 Ga.	61.75 feet/Ohm	62 feet/Ohm
24 Ga.	38.54 feet/Ohm	40 feet/Ohm
25 Ga.	30.87 feet/Ohm	31 feet/Ohm
26 Ga.	24 feet/Ohm	24 feet/Ohm

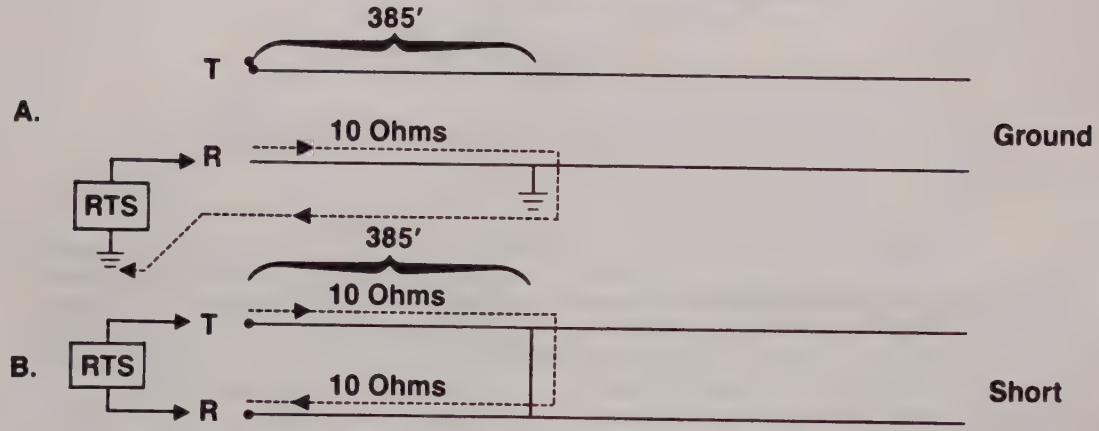
If a conductor is grounded, Ohms will convert to actual distance to fault (see fig. 2-A). Measuring a solid short actually takes a loop measurement through the short and back to the set. Therefore, the resistance must be divided by 2 before converting the gauge and temperature to an equivalent electrical footage (see fig. 2-B).

Several cable design factors must be accounted for to obtain the true distance-to-fault along a cable sheath.

1. Wire size (gauge): As the diameter of a conductor increases, the resistance decreases, and the number of feet per Ohm will increase.
2. Temperature: As the temperature of a conductor increases, so does resistance, and the number of feet per Ohm will decrease.
3. Type of metal used: Aluminum conductors (such as 17 and 22 gauge) and copper with steel additives (as in "B" Service wire) have more resistance than copper, and the number of feet per Ohm will decrease.
4. The helical design of the cable core: When a cable is manufactured, a twist is put in the pair for good pair-to-pair and pair-to-shield capacitance. This will eliminate power and noise problems. A twist is also put in the sub-units and groups to eliminate cross-talk and to make the cable flexible. A lay is put in the cable before the sheath is placed to provide "give" during installation and temperature changes.

Figure #2

10 Ohms of 24 Gauge at 68° = 385 feet.



20 Ohms ÷ 2 = 10 Ohms of 24 Ga. @ 68° = 385 feet.

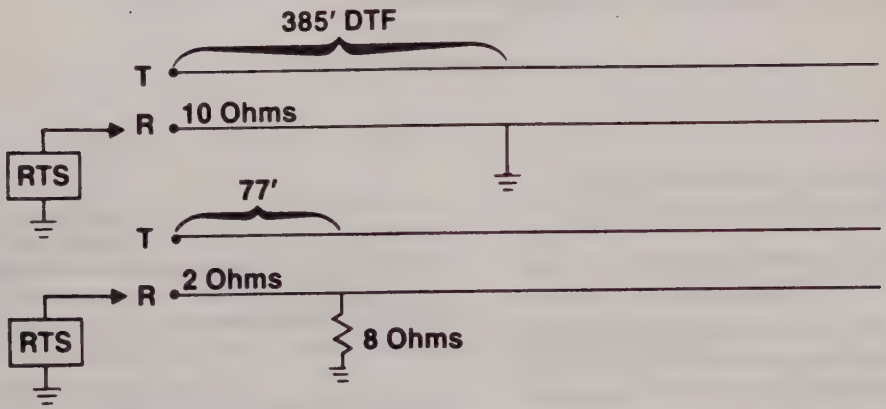
Current Flow ----------→

When converting Ohms to feet with the RTS in either the automatic "Pair Test" routine (MAIN MENU #2 PAIR TEST), the "Ohms Fault" routine (MAIN MENU #4: MANUAL TESTS, Submenu #2), or the "Ohms Ft" routine (MAIN MENU #7: UTILITIES, Sub Menu #4), variables such as gauge, temperature, and whether measured resistance is a short or ground are taken into account automatically, and a footage measurement to the fault is indicated on the display.

REMEMBER: the short or ground measured must be a zero-Ohm fault to give an accurate footage measurement (see fig. 3). Any resistance between ring and tip when measuring a short, or between a conductor and ground on a ground measurement, will increase the measured distance to the fault. As an example, an Ohm reading of 10 Ohms in 24 gauge at 68 degrees would be either at 385 feet, or closer than 385 feet.

Figure #3

10 Ohms of 24 Ga. at 68 ° = 385 feet



Wire resistance = 2 Ohms
Ground resistance = 8 Ohms

10 Ohms of 24 Ga. @ 68° = 385 feet

DTF (Distance To Fault) reads 10 Ohms or 385 feet
actual distance is 2 Ohms or 77 feet

If the resistance is not solid, use the CTC 4930A Conductor Fault Locator, strap the pair beyond the fault, set the gauge and enter temperature. After nulling, the resistance bridge will indicate the distance to the fault from the set, and from the far-end strap back to the fault.

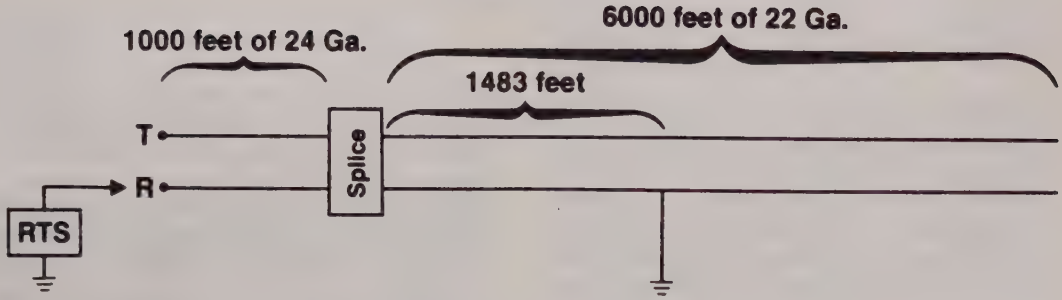
When measuring the distance to a fault in a cable run having more than one gauge size, resistance must be converted for each gauge. For example, an Ohms measurement of 50 Ohms to ground would be converted to 1,927 feet of 24 gauge cable (at 68 degrees F). If only 1,000 feet of cable in the direction of the fault is 24 gauge (as indicated on the cable map) and the rest 22 gauge, the remaining 927 feet would have to be converted to 22 gauge (see fig. 4). Thus:

1,927 feet measured with the Repair Test Set
-1,000 feet of 24 gauge according to the cable map
= 927 feet of 24 gauge to be converted to 22 gauge

Using the conversion table below, the multiply-factor for converting 24 gauge to 22 gauge is 1.6 Thus,

— 927 x 1.6 = 1,483 feet into the 22 gauge or
— 2,483 feet from the RTS to the fault.

Figure #4



RTS = 1927′
-1000′ of 24 Ga.
927′ of 24 Ga. to be converted
X 1.6
1483′ of 22 Ga.

1000′ of 24 Ga.
+ 1483′ of 22 Ga.
2483 actual distance to fault

The conversion table lists the multiplication factors for conversion to equivalent lengths in all common gauges.

The RTS provides an on-screen, four-function calculator which will perform these calculations (see MAIN MENU #7: UTILITIES, Submenu #10)

Conversion Table for Equivalent Length in Another Gauge

To Convert	To	Multiply By
19	22	0.497
	24	0.31
	26	0.193
22	19	2.01
	24	0.624
	26	0.389
24	19	3.22
	22	1.6
	26	0.623
26	19	5.18
	22	2.57
	24	1.61

PAIR FAULTS

Pair faults fall into two major catagories: Single Pair and Multiple Pair.

1. Single Pair faults

A single pair fault is trouble that has interrupted only one subscriber's service in a telephone cable. The majority of the faults, whether resistive or capacitive in nature, will be found in some form or ready access terminal or closure. Nationwide, 77.4% of all cable faults within 2,000 feet of the customer are in a ready access plant. They are caused by human error (a technician performing a previous task in that terminal has inadvertantly disrupted customer service), by power or lightning burning a carbon, or by rodent and insect damage.

2. Multilple Pair faults

When more than one pair is faulted, the cause will often be water in the cable core, or water in a splice or encapsulation. Damage to the sheath, such as a stake in the cable, a shovel cut, or damage by heavy equipment, will also show multiple pair faults. Many times, a cable fault can be a combination of sheath damage and water in the cable.

When multiple faults are suspected, test several pairs in the cable. For example, if the subscriber works on binding post 6, test pairs 1-10. Disconnect C.O. battery and ground from any working pairs. Use the RTS to analyze any resistance faults, using either the automatic "Pair Test" routine, or the manual routine. This will test for opens, resistance faults (Ohms faults) and leakage.

When measuring resistance in the 2K to 50k Ohm range between the ring and tip of several pairs, and finding 48Vdc Cross-battery both ring and tip to ground,

— suspect a wet pulp insulated cable.

If the RTS indicates high resistance faults measuring in the 100-800K Ohm range, or with battery crosses on the ring conductors only,

— suspect water in PIC cable and no sheath damage.

When cable faults are narrowed-down to a section, remove the bonds to isolate the shield. Use the RTS to measure for D.C. voltage on the shield (MAIN MENU #5: 2 TERMINAL METER, Submenu #1: Volts). A D.C. voltage indication anywhere from -15Vdc to -30Vdc will confirm that there is no sheath damage.

If the faulted conductors are shorted, grounded with crossed battery on the tips, and some tips open,

— the problem is a faulted splice or encapsulation.

When solid and light resistance faults plus opens are indicated,

— suspect damage to the cable sheath.

The average mutual capacitance of exchange cable is .083 microfarads per mile. The cable from the manufacturer can vary from .076 to .090 microfarads per mile. Therefore, the longer the distance to the open, the more possibility for error in measurement. The tendency for inaccuracy is usually blamed on the open meter, and capacitance deviations in the cable are not taken into consideration. For example, if the distance is 10,700 feet to an open and the cable capacitance is .090 microfarads per mile, an open meter set at .083 microfarads per mile, would indicate the open at 12,000 feet. This average .083 microfarads setting is acceptable for open measurements to an access, but when the cable sheath is to be opened or a pit dug for a buried fault, calibrate the CTC 4910G Open and Split Fault Locator to a known length on a good open conductor, and then measure distance to the open.

When using the RTS to measure an open (MAIN MENU #4: MANUAL TESTS, Submenu #1), use a good ground such as the cable strand or the bond bar in a buried terminal. The RTS automatically tests for an acceptable ground. If the ground tests as unacceptable, suspect a poor ground or an open ground cord. If a bad cord is suspected, self test the RTS. If the ground is bad, clean or remake the ground connection on the cable.

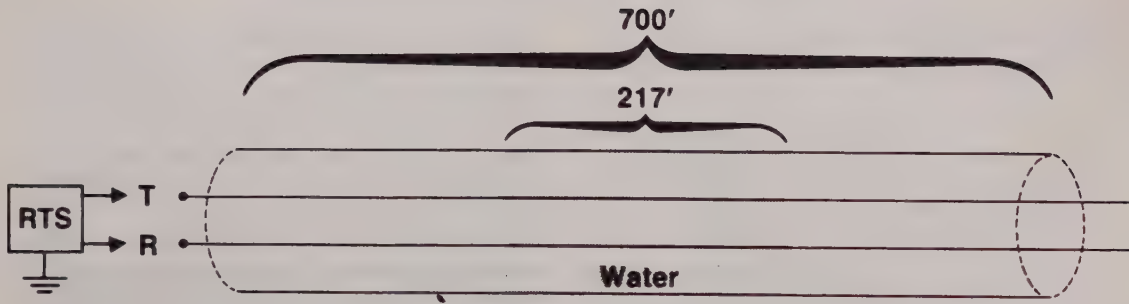
When measuring in a filled cable, the capacitance to ground increases. When fill is added to cables at the factory for protection from water, the capacitance increases by about 28%. To decrease this mutual capacitance, manufacturers have made many changes to the insulation, and filled cable mutual capacitance has been brought down to .083 microfarads per mile. The capacitance ring-to-ground or tip-to-ground remains at .092 microfarads per mile. The RTS uses a measuring technique which compensates for this increase.

The RTS calculates the amount of water in the cable core by comparing the percentage of

measured increase over a reference capacitance. Use the MAIN MENU #6: CUSTOM TEST, then select "2 Cap Variance." The RTS will indicate a percentage increase which is used to calculate the amount of water in the section. For example, if the RTS indicates a 31% increase in a 700 foot section, multiply 700 × 31% = 217 feet of water (see fig. 5).

The RTS can effectively identify the type of service trouble, and in many instances indicate where the fault exists. When service is restored and the automatic "Pair Test" (MAIN MENU #2: PAIR TEST) routine indicates all faults are cleared, a transmission test should be run to measure and analyze transmission characteristics.

Figure 5



RTS Capacitive Variance = 31%

700
x 31%
Water in cable 217 feet

LOOP TRANSMISSION MEASUREMENTS (LTM)

LTM is a plan for collecting transmission measurements on subscriber loops. All loop transmission measurements should be performed at the subscriber protector in order to test the quality of the entire circuit. LTM is programmed to help analyze exactly where transmission troubles are located, give an indication of what is causing the problem and provide information for the correction of service related trouble reports. A good LTM plan is designed to measure and record five basic Loop Transmission parameters:

1. Loop Current
2. Circuit Loss
3. Circuit Noise
4. Gain/Slope
5. Ground Ohms

LOOP CURRENT

(MAIN MENU #3: TRANSMISSION TEST, Submenu #1)

Loop current in milliamperes (mA) is measured to the Central Office. Current measurements to dial tone, without the resistance of the subscriber set in the circuit, are unacceptable for LTM, as a subscriber set can add from 150 to 400 Ohms to a loop. Therefore, a dial tone reading will not measure actual working loop current. When measured to the Central Office, the loop current is the same as "talk battery" current supplied to the telephone set user. The RTS will simulate a 430 Ohm subscriber set when making current measurements.

One of the most important factors in furnishing good service is sufficient loop current to provide "talk battery" and operate supervision and signaling equipment. Sufficient loop current is required for:

- Dial tone request
- Touchtone pad operation
- Ring trip when a call is answered
- "Talk battery" to the telephone transmitter

Insufficient loop current may be responsible for customer trouble reports such as:

- No dial tone
- Reach wrong number
- Can't be heard
- Bell rings - can't answer

Loop current is measured in milliamperes (mA) and obeys the law that governs current in any electrical circuit: Ohm's Law. Ohm's Law states that current (I) in a circuit is equal to the applied Voltage (E) divided by the total circuit resistance (R). Thus:

$$I=E/R$$

For example, the following resistances are measured in a loop (See Fig. 6):

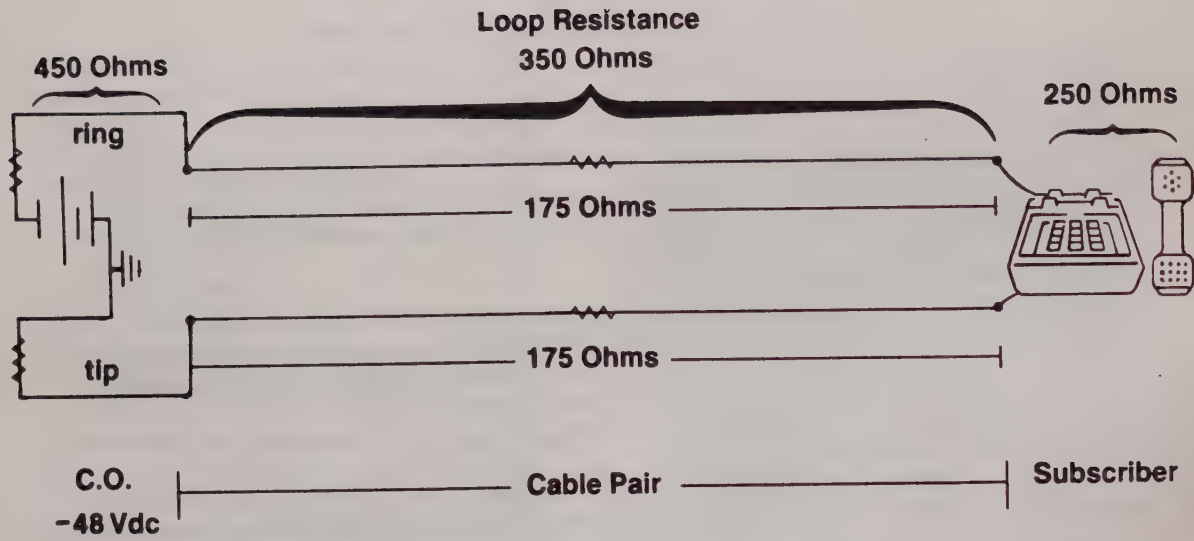
C.O. resistance	450 Ohms
Cable Pair	350 Ohms
Customer Equipment	250 Ohms
Total:	1050 Ohms

To calculate current, I = 48 (Vdc)/1050 (Ohms)

I = 45 mA

Thus, the current available to the subscriber, when he picks up the receiver, is an acceptable 45 mA. The voltage is supplied by the Central Office battery. This is normally -48 to -52 Vdc depending on the office, unless loop treatment (a Range Extender with Gain [REG] unit or a Dial Long Line [DLL] unit) is present. A REG increases voltage to approximately -80 volts and a DLL to -96 volts. See (MAIN MENU #4: MANUAL TESTS, Submenu #6, Loop Devices).

The resistance is a combination of the Central Office equipment plus the resistance of the C.O. battery (normally totaling 450 Ohms), the resistance of the cable pair including load coil resistance or buildout circuits, the resistance of the customer's telephone equipment (varies from 150 to 400 Ohms), the station wire (10 Ohms), and series devices (20 Ohms).



Current = 45 mA (acceptable)

Figure #6

The design and operation of a normal loop is such that adequate loop current will be provided on most loops. The minimum requirement in most telephone companies for a telephone set is 20 mA into a 430 Ohm (subscriber) resistance.

When the loop current falls below 23 mA, the telephone transmitter looses efficiency. The customer must talk louder than normal to be heard. The person at the far end may complain of "low volume" while the customer may report "can't be heard."

Marginal current problems (20-23 mA) can usually be corrected by boosting the voltage in the C.O. with loop treatment.

If loop current falls below 20 mA, additional problems may occur:

- The C.O. cannot sense off-hook conditions.
- Dialing problems occur.
- The customer's phone rings and cannot be answered or rings after the customer answers.

Low loop current problems are caused by physical trouble on the line such as a short, ground, cross, battery cross, or series resistance (going open).

Note: If loop current is unacceptable (too low), this condition must be corrected before other transmissions tests are meaningful.

CIRCUIT LOSS

(MAIN MENU #3: TRANSMISSION TEST, Submenu #3)

The basic task of a telephone circuit is to get a signal of the necessary amplitude to the end of a pair. As an electrical signal moves along the pair, it is attenuated (its amplitude is diminished) by four primary electrical factors:

— Conductor Resistance
— Insulation Loss
— Capacitance
— Inductance

Circuit Loss testing determines that the circuit will provide the correct talking volume.

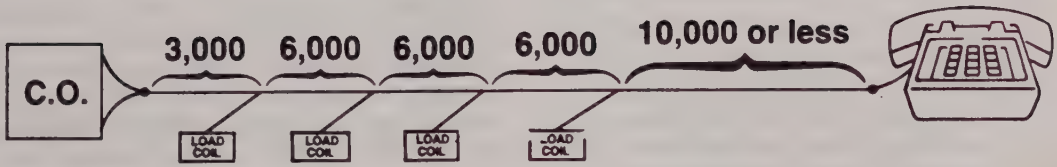
Circuit Loss is a measure of the signal power lost between the milliwatt supply of the Central Office and the customer protector. This loss is due to the capacitive characteristics of a circuit and is measured in decibels (dB). A generated tone of 1,004 Hz at 0 dB is used for measurement, and the loss determined by the attenuation of that frequency from origin to the test set.

Mutual capacitance (the capacitance across a pair and between each conductor and the cable sheath) is specified for every cable. As the length of a cable pair increases, so does capacitance. Fiqure 7 graphs the attenuation of signal due to capacitance in a non-loaded circuit. Note that the signal becomes marginal at a loss of 8 dB and is unacceptable at a loss greater than 10 dB. To offset excessive capacitance, load coils are used in any circuit longer than 18,500 feet. Careful attention must be given during plant design and construction phases to build an exactness into the load coil spacing.

The first load coil is normally placed at 3,000 feet from the C.O. and at 6,000 foot spacing thereafter (see fig. 8). When a call is placed, the called party also has a load at 3,000 feet from his C.O., and the 6,000 foot spacing is maintained. The subscriber must be less than 10,000 feet beyond the last load.

Figure #7
Non-Loaded Loop
Loss

Figure #8



Load Spacing

Circuit loss measurements will indicate the drop or attenuation between the Central Office and the customer. Excessive loss generates customer complaints such as "can't call out" (on a touchtone circuit), "can't hear" or "can't be heard." Since the human ear cannot determine loss, the circuit may sound good but may not meet requirements. Excessive loss will generate "repeat reports" on all voice calls.

Circuit loss is affected by the capacitance of the entire circuit including laterals and wire beyond the subscriber. Laterals and cable pair beyond the subscriber will add capacitance across the tip and ring (see fig. 9). This will shunt a portion of the signal causing a drop in level. Such loss occurs more at higher frequencies than lower frequencies and will change the slope of the circuit. The slope of a circuit graphs loss at different frequencies (see MAIN MENU #3 TRANSMISSION TEST, Submenu #4 Gain/Slope). Loop current tests alone may not indicate loss problems.

Load spacing will also affect circuit loss. If a load is missing or not placed at the right interval, circuit loss will be increased.

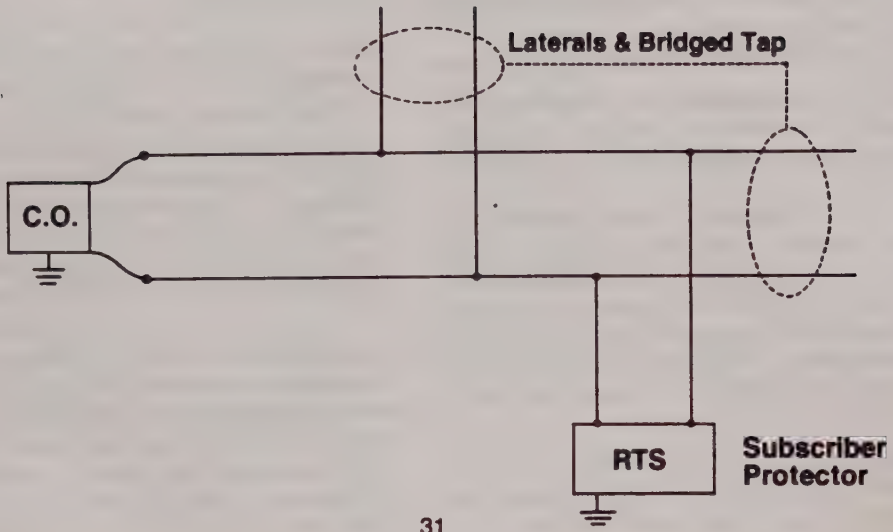
All P.O.T.S. circuits longer than 18,500 feet should be loaded. This measurement includes any laterals in the circuit. The factors that affect circuit loss are:

- — Switching loss in the Central Office.
- — The engineering design of the cable circuit, which includes such factors as gauge, type of insulation, cable length, load spacing, and the amount of bridged tap.
- — Low Loop Current.

Circuit loss objectives in most operating companies are as follows:

- — Acceptable: 8.5 dB or less.
- — Marginal: greater than 8.5 dB but less than or equal to 10 dB.
- — Unacceptable: greater than 10 dB.

Figure #9
Circuit Loss



In many areas, service is provided with extremely long loops and low density. It would be uneconomical to gauge the cable to bring all customers within the particular Central Office design limits. Instead, loop treatment devices are used. The need for loop treatment is determined by the type of Central Office and the resistance of the customer's loop.

If loop current is low and loss tests marginal or unacceptable, depending on the length of the circuit, loop treatment may correct the problem. This usually can be determined by disconnecting C.O. Battery, shorting the pair, and measuring loop resistance. A resistance greater than zone 13 (1,300 Ohms) may need loop treatment.

Loop treatment adds either a Range Extender With Gain (REG) or a Dial Long Line (DLL) to the circuit to increase loop current.

A REG is used when loop current and circuit loss are both marginal or unacceptable.

A DLL is used where circuit loss is acceptable and loop current is marginal or unacceptable.

If a DLL is used where loop current and circuit loss are marginal or unacceptable, an E6 repeater must be used to boost the loss to an acceptable level.

If low loop current is not a problem, check for loading errors or laterals. Keep in mind that there could be design errors by engineering, a defective or wrong value load coil, defective cable delivered from the manufacturer, or the wrong capacitance of cable. Splicing errors contribute to missing or reversed loads.

REMEMBER: Extended laterals or excessive cable pair beyond the customer increase capacitance and create a circuit loss problem.

Resistance design limits are determined by the type of Central Office equipment. Resistance Zones are predetermined by engineering and indicate the possibility of loop treatment. Constant monitoring at the protector will insure that design parameters are met as the plant environment changes.

Resistance Zone (RZ) by Type of Office

Resistance in Ohms	Crossbar (1300 Ohm)	Crossbar (1540 Ohm)	ESS
0-1300	RZ13	RZ13	RZ13
1301-1500	*RZ15	RZ15	RZ15
1501-2000	*RZ18	*RZ18	*RZ18
2001-2800	*RZ28	*RZ28	*RZ28

* indicates loop treatment may be needed

CIRCUIT NOISE

(MAIN MENU #3: TRANSMISSION TEST, Submenu #2)

Noise is any random disturbance or unwanted signal in a communication system which tends to obscure the clarity of signal to the detriment of service. Circuit noise is caused by spurious induced electrical signals which interfere with normal transmission of voice and data. The amount of noise is usually a subjective determination, but when it generates a customer complaint the trouble must be cleared.

The measurement of the power of a signal received above a reference power of 1 milliwatt is expressed in dBm. 0 dBm is equal to 1 milliwatt of power.

Reference Noise is the loudness of a signal at the protector, compared with what it was in the C.O. and referenced to 1,000 Hz at a fixed power output. The Reference-for-Noise measurement (dBm) is determined to be a level equivalent to a tone at -90 dBm. Thus, 0 dBm is equal to -90 dBm. 0 dBm is equal to 90 dBm.

Noise Metallic (Nm) can be heard by the customer and is measured across the tip and ring of a circuit. This is sometimes referred to as "line born noise" because it is foreign energy induced somewhere along the telephone circuit. It is the same as circuit noise and is measured in units of dBmC. The "C" represents message weighting. C-message weighting uses a filter to eliminate all noise on a test line which is outside the range of human hearing. The sensitivity of the ear drops at frequencies below 800 Hz, and above 2500 Hz. C-message weighting filters out all noise above and below this range, and makes the RTS react to circuit conditions as the human ear would. Thus, when measuring "line born noise" with the RTS and the noise metallic is acceptable according to the meter, it is also acceptable to the customer.

Although there are many sources of "line born noise," the noise measured with the RTS is noise induced into the telephone circuit by adjacent

power lines. Current flowing in the power lines creates an electromagnetic field. Any telephone cable in close proximity is sympathetic to induced power influence (see fig. 10). The RTS permits this influence to be measured. In a situation where there is a circuit path to ground when a quiet line termination is dialed, there is induced current on each conductor of the test pair. If ring and tip capacitance is balanced, no current flows to ground, as the A.C. current flow between the ring and tip conductor is equal and opposite and will cancel. If the circuit is unbalanced either resistively or capacitively, current equal to the difference between the two conductors will flow to ground.

Thus, circuit noise is a function of the A.C. power flowing in the cable pair and the balance in capacitance between the ring and the tip of the pair.

Circuit Noise, Power Influence, and Circuit Balance are interrelated. Each is dependent upon the other to form acceptable circuit balance, and must be measured with the following formula in mind:

$$P_I - N_m = \text{Balance}$$

To calculate circuit balance, subtract circuit noise, which should be 20 dBmC or less, from the power influence, which should be 80 dBmC or less. Therefore, circuit balance must be 60 dB or greater to be acceptable.

A slight caution:

Because of the above limits, if power influence drops below 60 dBmC, the balance of the circuit is not measurable. However, if the power influence **constantly** remains below 60 dBmC, the customer will never complain of a marginal noise problem. It is when the power influence fluctuates in strength (such as under peak and minimum loads) that repeat complaints of noise occur. In this case, with a close to marginal noise metallic reading, it is advisable to raise the power influence artificially to test circuit balance. Add a bridging transformer to the circuit. Next, use a

Figure #10

Induced AC Power

tone generator from another RTS to induce a constant A.C. signal (577.5 Hz) into the circuit. Again measure noise metallic and power influence. Even if the artificial power influence is above 80 dBmC, if the balance is greater than 60 dB, it is acceptable. If the balance is less than 60 dB and circuit noise is marginal or unacceptable,

— look for pair trouble.

Use the RTS to measure capacitive balance. If the ring or tip reads longer,

— check for a lateral with one side open or

— check the wire beyond the customer for one side open.

If capacitive balance is acceptable, short and ground the pair at the C.O. Measure the ring and tip for resistive balance. An increase in resistance on either conductor indicates:

— a bad splicing connector or

— the pair going open due to water in the splice.

If the balance is less than 60 dB and the power influence is more than 80 dBmC,

— check for grounding or bonding problems.

Disconnect the customer and read circuit balance again with the RTS. Any decrease in noise metallic or power influence by more than 3 dB indicates:

— the problem is on the disconnected side.

If there is no change, repeat the test at the workout terminal. If still no change, retest at the cross-connect box.

REMEMBER, a bridging transformer is required at any isolation point after the workout terminal to calculate balance by measuring noise.

NOTE: Any high-resistance insulation troubles (which can be heard as static noise) may be misconstrued as transmission noise. Always test pair insulation for such faults (MAIN MENU #4 MANUAL TESTS, Submenu #5, Leakage) and correct them before proceeding with transmission tests.

When water in a PIC cable or a splice causes high resistance faults due to electrolysis, the

usual complaint from the subscriber is "noise" or "static" on the pair. If the cause of the problem is not found, the technician's alternative is simply cut-to-clear, switching service to a vacant good pair in the same count. Even though battery has been removed and the electrolysis stops, the faulted pair will now be affected by galvanic corrosion (transfer between two dissimilar metals, in this case the aluminum shield to copper conductor) to the point where the fault will be resistively masked. When the pair is retested for possible use, no trouble will appear, but electrolysis will begin instantly again if the pair is put into service. The RTS Leakage test applies 100 Vdc to the pair under test. Voltage is applied across the pair (tip-to-ring), then ring-to-ground and tip-to-ground. This test will identify electrical leakage through the insulation or leakage at a splice or damage spot. Always use this test before cutting to a vacant pair in the field.

GAIN/SLOPE

(MAIN MENU #3: TRANSMISSION TEST, Submenu #4)

Slope is the graphed difference in circuit loss between the high and low frequencies of a telephone circuit. The lower frequencies (around 1,000 Hz) control loudness; high frequencies control the quality of the circuit — how well it sounds. Slope should be measured from the workout terminal or the protector. If slope is incorrect, the customer will complain of:

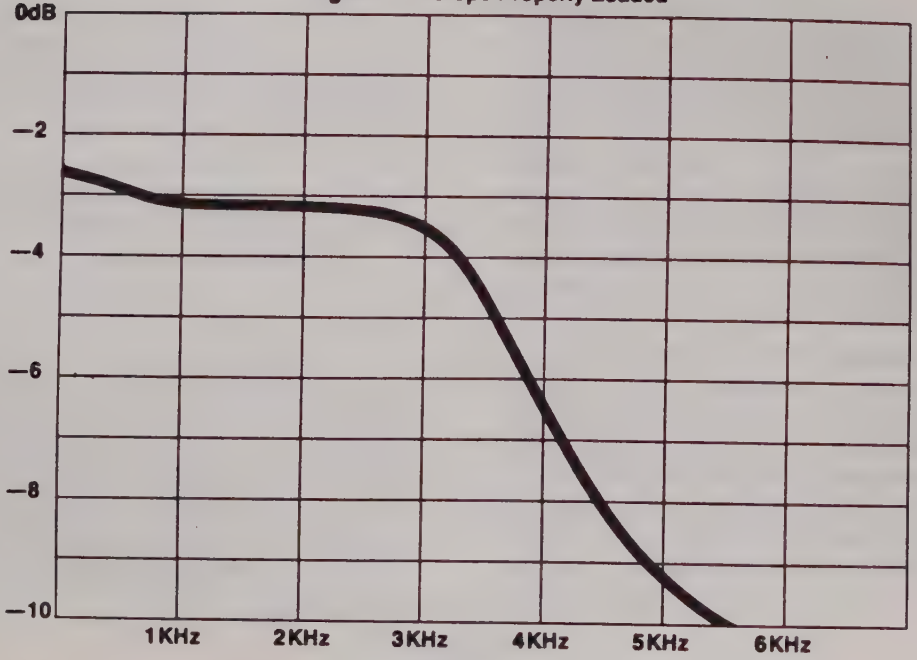
— Can't call out at times, reach wrong numbers,
— Can't hear at times,
— Squeals (if treatment is on line),
— Data transmission fails (Fax equipment, data modem, etc.),
— Fades in and out.

The RTS automatically measures the loss at 404 Hz, 1,004 Hz, and 2,800 Hz to test for acceptable slope. An increase of over 7.5 dBm between two readings shows unacceptable loss in the circuit and indicates a loading error. The engineer limits slope by proper loading and by controlling bridged taps (laterals). Loading is a design technique for adding lumped inductance at regular intervals to counter the effect of distributed capacitance.
The maximum length of a non-loaded circuit is 18,500 feet. Beyond this distance, capacitance will be too great to allow the 7.5 dBm slope differential, and proper loading is required.

Simply talking over the circuit will not indicate acceptable slope. Since higher frequencies are more affected by capacitance than are lower frequencies, women and childred find the circuit unusable, while a lower-frequency male voice will find no problems.

Loading a cable reduces the loss across the voice band (300 Hz to 3,000 Hz) and flattens out the frequency response curve (see fig. 11). This will attenuate all frequencies in the voice band approximately the same.

Figure #11 Slope Properly Loaded



Missing load coils, reversed load coils, or double loading of a pair will cause distorted response at different frequencies.

Bridged taps (laterals or excessive cable pair beyond the customer) act as lumped capacitance across the cable pair. Too much bridged tap can cause the 7.5 dB acceptable level to be exceeded. Loaded bridged tap will cause the signal to reflect back down the pair and cause excessive loss at two frequencies. If the affected frequencies are in the touchtone band, dialing difficulties can be expected. Touchtone dialing problems occuring on only one set can be attributed to the touch pad of the telephone set. This can be affirmed by using the RTS Touch Tone Dialing Check procedure (MAIN MENU #5 TWO-TERMINAL METER, Submenu #4 dBm/Hz Meter). If the telephone touch pad tests o.k., then check for a loop transmission problem.

To determine if Dual Tone Multi Frequency (DTMF) signaling is within limits, use the RTS to measure the loss in each frequency of a 5 or 9 tone steptone generator. Record the results on a copy of the graph (see fiq. 12). The response (loss in dB) should be flat from 400 Hz to 2,800 Hz, then taper off rapidly.

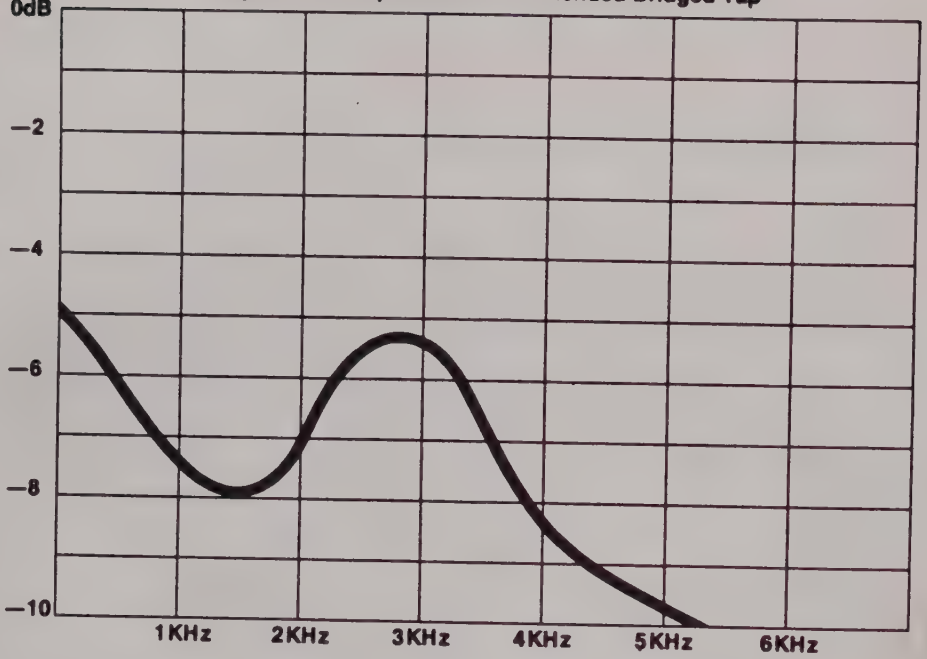
— A response as shown in fiqure 12 indicates missing, reversed, or double loading.
— A response as shown in fiqure 13 indicates loaded or extended bridged tap.

The RTS can be used on a dry line to send selected or variable frequencies. 404 Hz, 1,004 Hz and 2,804 Hz are used for Loss and Slope tests. 3,000 Hz and 5,000 Hz are used for testing special circuits that operate above the voice frequencies.

All frequencies are sent from -10 dB to +5. REMEMBER: The RTS does not time out automatically. Turn the set off after sending frequency.

Figure #12 Slope Missing Load

Figure #13 Slope Loaded on Extended Bridged Tap



GROUND OHMS

(MAIN MENU #4: MANUAL TESTS, Submenu #7)

This is a National Electrical Code (NEC) requirement

The Ground Ohms test measures the resistance between the Central Office ground and the ground at the customer's premises. The station ground should test at 25 Ohms or less. This will assure that the carbons at the protector will fire when power or lightning is present on the circuit and protect the customer and station equipment against possible damage.

If the station ground at the protector measures more than 25 Ohms, the technician must remake or replace the station ground.

Use the RTS MANUAL TEST, #7, "Ground Ohms," to test station ground.

NOTE: This test will provide inconclusive results when testing towards an ESS 5 Central Office.

C-9925 P/N 1842401

REPAIR TEST SET

Section II: OPERATOR'S MANUAL

COMMUNICATIONS TECHNOLOGY CORPORATION

DALLAS, TEXAS • (214) 991-8338

C-9925
OPERATOR'S MANUAL
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CTC C-9925 REPAIR TEST SET OPERATOR'S MANUAL

GENERAL

The C-9925 Repair Test Set (RTS) is a battery powered portable field test set which makes a wide variety of electrical tests and measurement on cable pairs. In addition, it performs a number of auxiliary functions such as automatic dialing, storing and printing test data, and tone sending. A handy four-function calculator is built in. This microprocessor-controlled, menu-driven testing computer is extremely easy to operate. The set is completely self-contained and self-powered. Test and Utility Function routines are displayed in menu form and called up with the press of a key. Convenient studs are provided for the attachment of a handset, and an interface jack attaches an accessory printer to provide hardcopy of test results.

OPERATION

A list of the RTS menus is printed on the cord storage box in the lid or on the lid of the C9917 Convenience Bag. The control panel consists of the following elements:

1. The START key turns on the set. When pressed during a test routine, the START key aborts the test and returns the display to the previous Submenu, until the Main Menu is reached.

2. The Test cords attach to the pair under test: red to ring: black to tip: green to ground. (not shown)

3. The LCD screen displays function menus, testing procedures, and test results.

4. The four directional arrow keys move the display to screens containing additional information. Depending upon the arrowhead(s) displayed, the display will move to a screen above, below, to the right or left by pressing the indicated cursor key. Whenever an arrow appears, more information will be displayed in that direction by pressing the key.

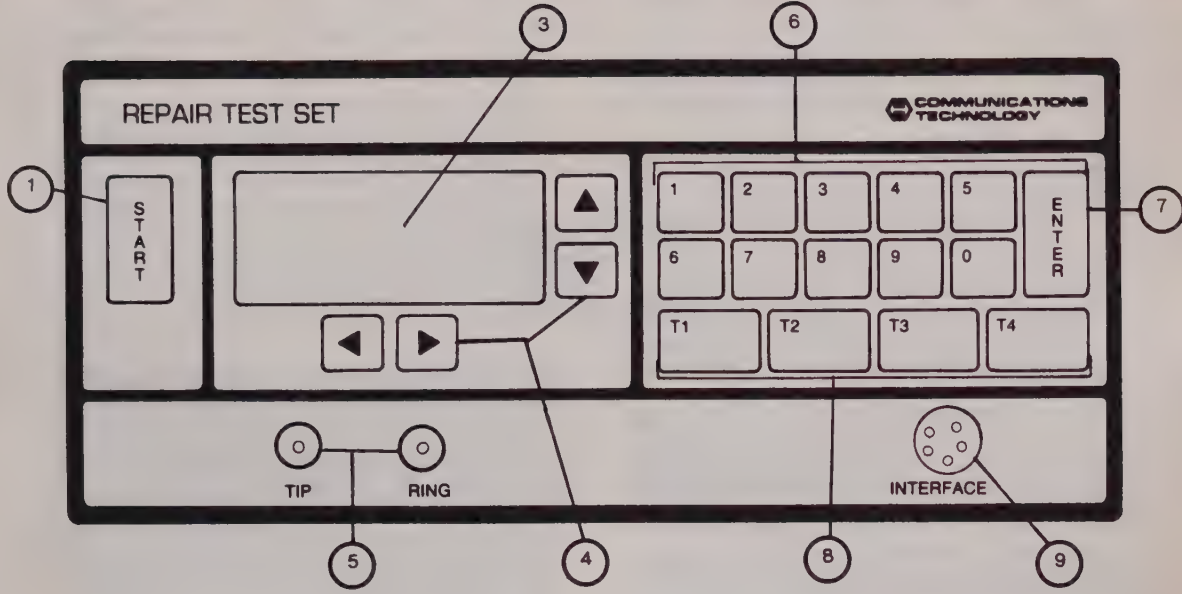
5. Tip and ring studs for easy attachment of a handset to the pair under test.

6. The numbers keypad. These keys select menu choice and enter data such as cable temperature and phone numbers. Each key gives an audible beep when pressed to confirm the RTS has registered its selection.

7. After a key or a series of keys has been pressed, the ENTER key informs the RTS that a choice has been made or the entry is complete.

8. The four FUNCTION keys. These keys (T1, T2, T3, T4) can be programmed to perform a repetitious series of tests in order and to enter mathamatical functions in "Calculator" mode. T1 and T2 provide the * and # of a touchtone keypad. T3 will save test results to internal memory, while T4 will begin a print sequence of saved results when the accessory printer is attached.

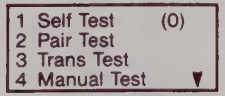
9. The accessory printer interface.


REPAIR TEST SET
COMMUNICATIONS TECHNOLOGY
START
1
2
3
4
5
6
7
8
9
0
ENTER
T1
T2
T3
T4
TIP
RING
INTERFACE
1
3
6
7
5
4
8
9

This manual describes the tests the RTS will perform and shows each step in the menu-driven operation. After pressing the start key, a menu (a set of choices) is first displayed as a numbered list on the Liquid Crystal Display (LCD), and the desired test sequence or a submenu of further functions is chosen by pressing the corresponding number and then the ENTER key. (Any test in the submenu can be selected without it being displayed on the screen.) The ENTER key tells the computer to proceed with the chosen routine. As the routine progresses, instructions and choices are displayed in logical order, and test results — which can be stored and printed — are shown.

The following exercise will demonstrate the menu functions, directional displays, and the keystrokes needed to move through test routines. Make sure the cords are clear.

Press the START key. Note that a menu of four choices is displayed. The arrow pointing down indicates a list of additional menu choices that will be displayed when the down arrow key is pressed.



The (0) in the upper right corner will show any number up to two digits entered on the numbers keypad. If a third digit is attempted, the display will return to (0). To erase an entry, press the left arrow key.

For this exercise, press #2. Note that the (0) in the upper right corner now reflects the choice, and confirms that the "Pair Test" routine is chosen. Press ENTER. The RTS checks for hazardous voltage. If the set finds hazardous voltage, it indicates this, displays the measurement and ends testing. If no such voltage is found, it proceeds to automatically test both sides of the pair and ground for resistive and/or capacitive troubles, and will show the test results on the screen. The "Pair Test" routines are shown in detail in the MAIN MENU #2 PAIR TEST section of this manual.

Note: #2 PAIR TEST should always be run when first attaching to a cable to check for voltage hazard and to monitor the line.

After using the arrow keys to view the test results, press START to return to the Main Menu display. This does not erase test information as the RTS stores the last set of data screens and returns to them when ENTER is pressed with zero (O) as the menu choice. The set's software version and identity message appears, with a down arrow displayed when there is data available from the last test. Press the down arrow and the data screens appear according to the arrow keys pressed.

The RTS performs two basic types of tests: static and dynamic. Most tests are static where the results are constant, such as Loss or Distance measurements. Such results are displayed on the screen and stored as single test values.

There are six dynamic tests performed by the RTS: Noise/P.I., D.C. Voltage, A.C. Voltage, Ohms, Capacitance, dB Hz Meter. In each of these tests, the RTS makes repeated measurements and the display reflects any change in the test values. The set displays the results of some of these tests in both digital (numerical) and analog (moving pointer on a scale) modes. Digital displays are accurate, but most useful if there is no change in values. The analog display shows the way measured values are changing, and is especially useful when the value changes rapidly or in some characteristic way.

The RTS features an automatic shut-off system to save battery life. If no key is pressed in a period of 45 seconds, a warning tone sounds. After an additional 15 seconds, the set shuts down. Pressing any key resets this shut down timer. When using the "Pair Access" utility to monitor the line with a handset, access will still be maintained after the automatic shutdown.

Automatic shut-off is disabled by three test routines which may require the set to operate unattended for long periods: the "Send Frequency" in the Transmission Tests menu, the "Send Tone" or "Dial" in the Utilities menu. With these tests, the set will operate continuously as long as the batteries last.

IMPORTANT: WHEN USING THE RTS SEND FREQUENCY, SEND TONE, OR DIAL, ALWAYS MANUALLY SHUT DOWN THE SET.

To manually turn the RTS off, press the START key repeatedly until the Main Menu is displayed, press the 8 key and then ENTER. The RTS will shut down.

Main Menu

The Main Menu lists eight choices by number, four of which are displayed at a time. Press START to start the RTS and display options 1 through 4. Press the down arrow to display options 5 through 8. Pressing any of these numbers will reflect in the (0) in the upper right corner. The routine need not be displayed in order to select its number (i.e. pressing 8 when the first screen 1 through 4 is displayed will still call "8 Power Off" and pressing ENTER will shut down the set).

The Main Menu displays a "Self-Test" routine (which should be run at the start of everyday in order to automatically check and calibrate the set) and an automatic "Pair Test" routine which checks the pair for resistive and capacitive faults. Each of these tests is automatic, and will direct the operator through the routine, and display findings.

Selecting routines 3 through 7 will display a series of Submenus which also have a choice display (0) and directional arrows indicating additional screens. As with the Main Menu, any choice is confirmed by pressing ENTER.

Initializing The RTS

There are several special codes which are used at the factory for test purposes. Pressing 97 then ENTER at the Main Menu resets all internal mechanical relays. Pressing 98 then ENTER also resets the relays and clears memory, erasing all phone numbers and saved case data.

NOTE: IF THE UNIT LOCKS UP (WILL NOT RESPOND TO KEYBOARD ENTRIES) OR THE SCREEN GOES BLANK, RESET UNIT BY DISCONNECTING AND RECONNECTING THE BATTERIES.

Press the ENTER key with zero displayed as a choice at the Main Menu and the serial number of the test set will be displayed. This information is permanently stored in RTS memory and cannot be changed or altered except at the factory. For customer protection, any attempt to alter this information will destroy the operating program and the RTS will no longer function.

NOTE: The number built into the test set and the number on the back of the set will normally agree. For the most dependable identification, use the information in the memory.

SELF TEST

Turn on set by pressing START; the following screen will appear.

```
1 Self Test      (0)
2 pair Test
3 Trans Tests
4 Manual Tests    ▼
```

Press #1 and ENTER

```
Alka batteries    ▲
Voltage: 8.53
Batteries: OK
Press START
```

NOTE: Alkaline Batteries will show low at 6.2 volts - NiCad will show low at 6.8 volts.

For NiCad batteries press UP ARROW

```
Nicad batteries   ▲
Voltage: 8.59
Batteries: OK
Press START
```

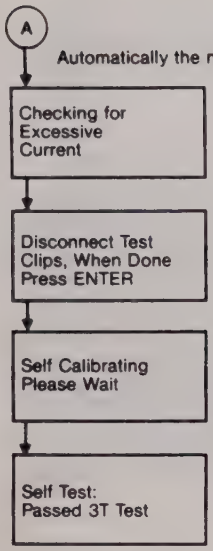
Press START and follow the direction on the screen.

```
Short
Tip & Ring to Ground
When Ready
Press ENTER
```

Run Self Test at the Beginning of the Day

Self Test is an automatic test routine which checks that the RTS circuits are operating correctly, and recalibrates the set taking the test-lead capacitance and resistance into account. To assure maximum accuracy, run self test for each new case or job.

With either battery type, the display will flash on and off when the voltage is low.


A
Automatically the next screen will appear.
Checking for Excessive Current
Disconnect Test Clips, When Done Press ENTER
Self Calibrating Please Wait
Self Test: Passed 3T Test

If the test fails, there is some problem. Check that the three test leads are not making electrical contact and repeat Self Test. If the battery voltage is low, a low voltage message will be displayed. In this case, change the batteries and retest. If the problem is something other than batteries, the set must be returned to the factory for service.

DO NOT USE FOR TESTING UNTIL THE SELF TEST IS PASSED.

MAIN MENU #2 PAIR TEST

This is an automatic test routine that will identify most abnormalities on the cable pair under test. Pair Test checks a cable pair, analyzes it, then displays what was found. It checks for hazardous voltage, identifies dry pairs (pairs with no voltage), pairs with unusual A.C. or D.C. voltages and POTS pairs. It displays whether the pair is idle or busy and the presence of any loop treatment. Pair Test:

—Tests A.C. and D.C. volts

—Test for Ohms faults

—Checks Leakage (high resistance)

—Tests for Opens

—Tests capacitance and balance

—Displays the length of test pair

There are many advantages to this routine. With one hookup and using only one test set:

—All necessary tests are made automatically

—Tests are made in the proper sequence

—The most significant fault is identified

—The routine warns if testing other than a POTS line

—Hazardous and unusual voltages are detected

The automatic test routine will stop when a fault is detected on the pair, and the findings will be displayed on the LCD. At this point, additional information may be requested; for example, when an Ohms fault is detected, the set will ask for entry of cable temperature in order to locate the fault. When a fault is detected, it must be cleared before the RTS will perform the remainder of the routine.

When multiple faults exist on a pair, the most significant fault must be cleared before testing can resume. Open and resistive faults must be measured on a dry line (without battery on the pair). Opens cannot be accurately measured with resistive faults on the pair.

These tests and three-terminal test measurements are comparable to Central Office MLT testing. The RTS results will match those of the maintenance centers.

The order of testing in automatic Pair Test is as follows:

1. Check for A.C. or D.C. voltage.
2. Look for low Ohms faults.
3. Apply 100 Vdc to check for leakage (high resistance faults) to 65M Ohms.
4. Test for Opens.

The results of each of these routines are displayed. If a fault is found, its nature is displayed and analyzed.It must be cleared in order to proceed to the next test.

Excessive mA Present

As a protection against damage to internal circuitry, the RTS measures tip-to-ring, tip-to-ground and ring-to-ground current before performing a test. If this current reading is too high, the set will abort the test and display the "Excessive Current Screen," below.

Excessive
Current
NN mA
XXXXXXXX

(Where NN = numeric value of current in milliamps, XXXXXXXX = "tip-to-ring," "tip-to-ground," or "ring-to-ground," depending on where the excessive current was found).

Disconnect From C.O.

Dry line tests such as opens and Ohm fault will provide inaccurate results when run on a hot pair. If the RTS detects voltage on the pair during these tests, it will abort and the message "Disconnect From C.O. for XXXX" will appear. (XXXX = Name of Test Being Performed). An open tip on a hot pair will measure.

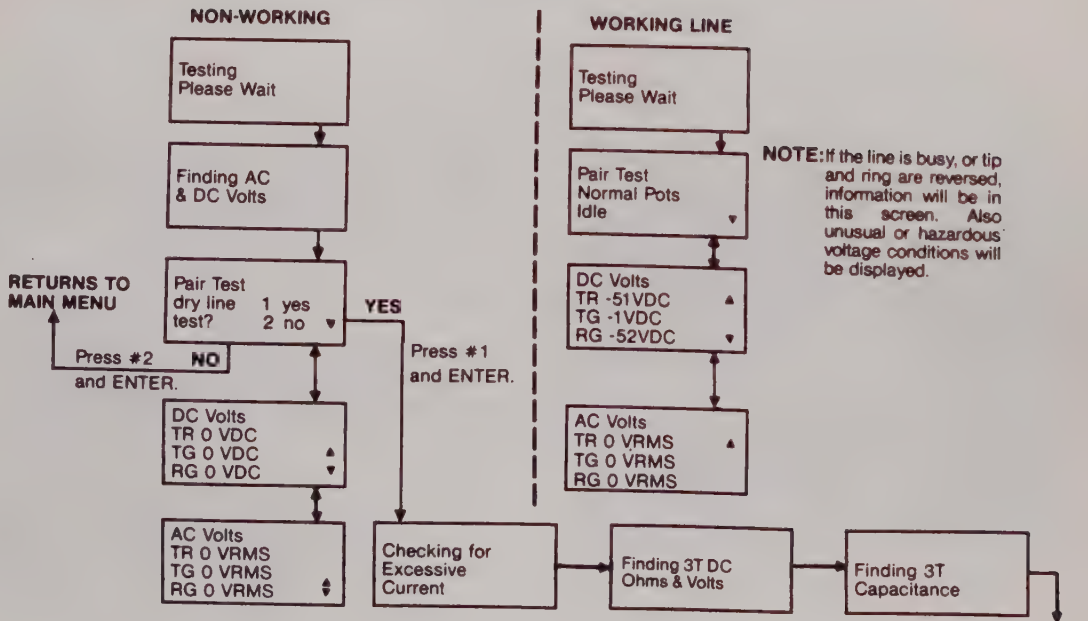
RTS Hookup

For all testing, the test leads are connected red to ring, black to tip and green to ground (preferably the cable shield, if possible). A known good ground is essential for accurate test measurements. Driving a screwdriver into the earth to obtain a good ground is insufficient and will result in inaccurate test results.

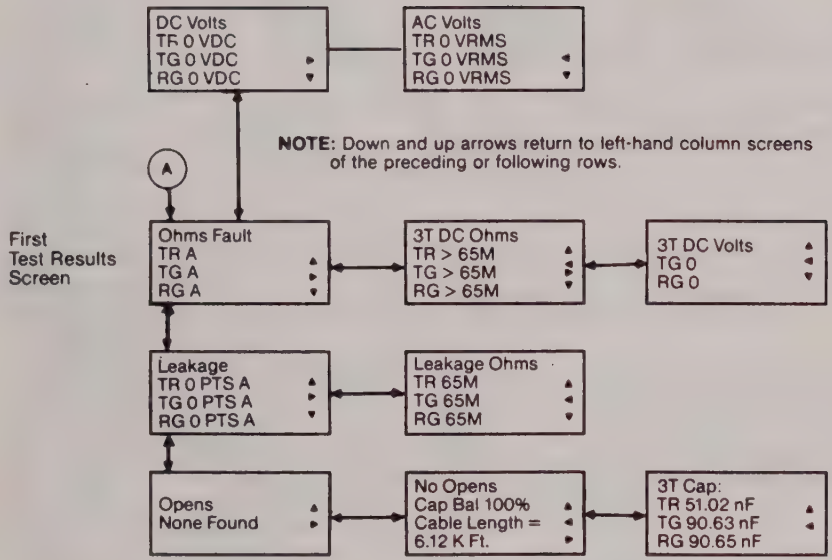
Following are detailed logic and explanatory material for all RTS test routines.

MAIN MENU #2: PAIR TEST (GOODPAIR)

Press #2 and ENTER



NOTE: If the line is busy, or tip and ring are reversed, information will be in this screen. Also unusual or hazardous voltage conditions will be displayed.


DC Volts
TR 0 VDC
TG 0 VDC
RG 0 VDC
AC Volts
TR 0 VRMS
TG 0 VRMS
RG 0 VRMS
NOTE: Down and up arrows return to left-hand column screens of the preceding or following rows.
A
First Test Results Screen
Ohms Fault
TR A
TG A
RG A
3T DC Ohms
TR > 65M
TG > 65M
RG > 65M
3T DC Volts
TG 0
RG 0
Leakage
TR 0 PTS A
TG 0 PTS A
RG 0 PTS A
Leakage Ohms
TR 65M
TG 65M
RG 65M
Opens
None Found
No Opens
Cap Bal 100%
Cable Length =
6.12 K Ft.
3T Cap:
TR 51.02 nF
TG 90.63 nF
RG 90.65 nF

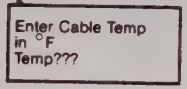
MAIN MENU #2: PAIR TEST (FAULT)

Pair shorted will appear as follows.

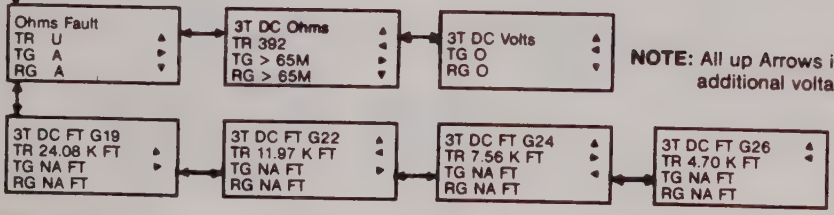
Press #2 and ENTER from Main Menu

NOTE: Down Arrow provides DC and AC Voltage Information.

Press #1 and ENTER



Press ENTER for automatic 68° Use the number keypad to input other cable temperature.



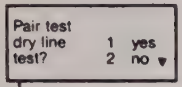
NOTE: All up Arrows in this row provide additional voltage information.

Check gauge of cable and find distance to fault.

MAIN MENU #2: PAIR TEST (FAULT)

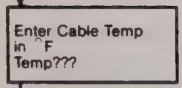
Ring ground will appear as follows.

Press #2 and ENTER from Main Menu

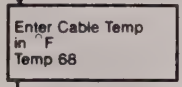


NOTE: Down Arrow provides DC and AC Voltage Information.

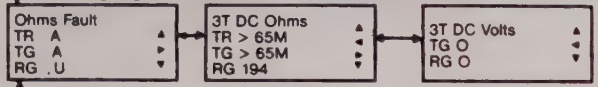
ENTER #1 for Dry Line Test



Press ENTER for automatic 68°. Use the number keypad to input other cable temperature.



Check gauge of cable and find distance to fault.

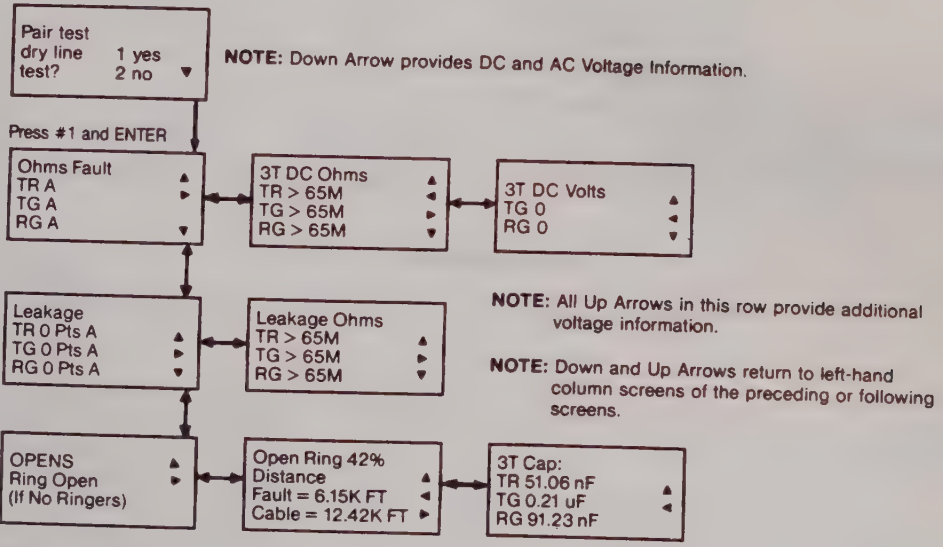


NOTE: Down and Up Arrows return to left-hand column screens of the preceding or following rows.

NOTE: All Up Arrows in this row provide additional voltage information.

MAIN MENU #2: PAIR TEST (FAULT)

Ring open will appear as follows:



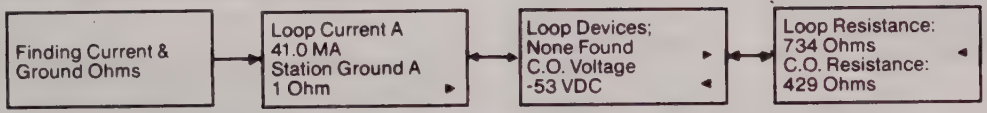
SUBMENU #1: CURRENT

Press #3 and ENTER to see the following Screen.

```
1 Current          (0)
2 Noise
3 Loss
4 Gain/Slope        ▼
```

Note: Pushing Down Arrow provides additional submenu screens.

Press #1 and ENTER to select Current test.



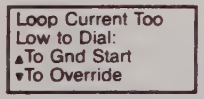
Note: If loop condition is unacceptable (too low) this condition must be corrected before other transmission tests are meaningful. The first step in noise testing is checking loop current and 1 KHz circuit loss measurement.

MAIN MENU #3: TRANSMISSION TEST

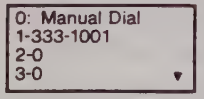
SUBMENU #2: NOISE

Press #2 and ENTER

NOTE: This screen appears only if connected to a ground start circuit or a pair that has insufficient loop current.

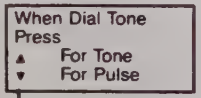


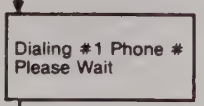
NOTE: This screen appears only if connected to a ground start circuit or a pair that has insufficient loop curcuit.

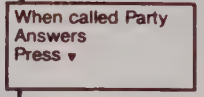


NOTE: Programmed numbers will be displayed. A zero indicates no number has been entered. Up to 9 phone numbers, of 12 digits or less each, can be entered. Press Down Arrow for additional number entry screens.

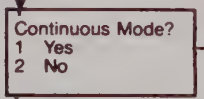
To obtain quiet termination, press its list number and ENTER. For manual dial press 0, ENTER, then phone number and ENTER.



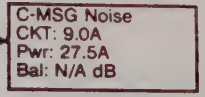




NOTE: Circuit noise and power influence work together. High noise with acceptable power influence indicates a pair problem. If power influence is high, suspect an open shield or poor or missing ground. If noise is still unacceptable after corrections, check pair balance.

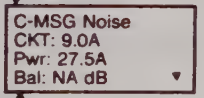


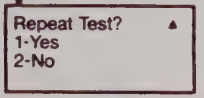
#1



Selecting #1 initiates continuous measurement which updates the display screen every 3-5 seconds for a period of 5 minutes.

#2





For "Yes," press 1 and ENTER: This repeats test.
for "No," press 2 and ENTER: This returns program to the start of Submenu #1: Current.

MAIN MENU #3: TRANSMISSION TEST

SUB MENU #3: LOSS

Press *3 and ENTER

```
Loop Current Too
Low to Dial:
▲To Gnd Start
▼To Override
```

NOTE: This screen appears only if connected to a ground start circuit or a pair that has insufficient loop current.

```
0: Manual Dial
1  0
2  0
3  0              ▼
```

To obtain 1,004 Hz tone, press its list number and ENTER.
For manual dial press 0, ENTER, then phone number and ENTER.

```
When Dial Tone
Press
  ▲ For Tone
  ▼ For Pulse
```

NOTE: Programmed numbers will be displayed. A zero indicates no number has been entered. Up to 9 phone numbers, of 12 digits or less each, can be entered. Press Down Arrow for additional number entry screens.

(A)

(A)

```
Dialing #1 Phone #
Please Wait
```

```
When Called Party
Answers
Press ▼
```

```
CKT Loss: A
Level: -3.5 dBm
Freq:  1.01K Hz
```

MAIN MENU #3: TRANSMISSION TEST

SUB MENU #4: GAIN SLOPE

Press #4 and ENTER

```
Loop Current Too
Low to Dial:
  ▲ To Gnd Start
  ▼ To Override
```

NOTE: This screen appears only if connected to a ground start circuit or a pair that has insufficient loop current.

```
0: Manual Dial
1  0
2  0
3  0                ▼
```

To obtain step-tone generator, press its list number and ENTER. For manual dial press 0, ENTER, then phone number and ENTER.

```
When Dial Tone
Press
  ▲ For Tone
  ▼ For Pulse
```

NOTE: Programmed numbers will be displayed. A zero indicates no number has been entered. Up to 9 phone numbers, of 12 digits or less each, can be entered. Press Down Arrow for additional number entry screens.

(A)

(A)

```
Dialing #1 Phone #
Please Wait
```

```
When Called Party
Answers
Press ▼
```

NOTE: Unit will display gain/slope readings as they are being measured.

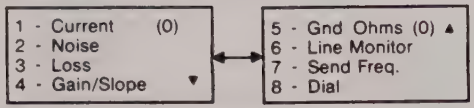
```
Slope: 5.7 A
 404  Hz: - 3.2
1004  Hz: - 1.5
2804  Hz: - 7.2
```

NOTE: Refer to circuit design for acceptable limits.

NOTE: If fewer than three tones are detected, slope is not computed. If more than three measurements are detected, Down Arrow appears, providing access to up to eight more frequency measurements.

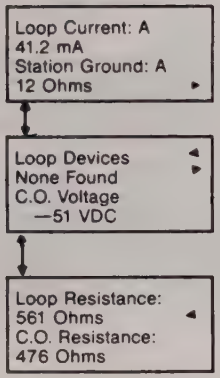
MAIN MENU #3
TRANSMISSION TEST
SUB MENU #5: GROUND OHMS

From Main Menu press #3 and ENTER to see the following screen.



Press Down Arrow to select next submenu screen.

Press #5 and ENTER to select the fifth test, Gnd Ohms.

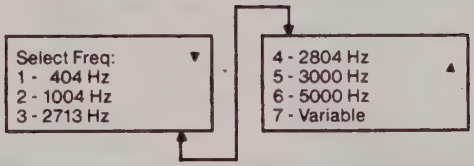


MAIN MENU #3:
TRANSMISSION TEST
SUBMENU #6: LINE MONITOR

Press #6 and ENTER. This allows the circuit your set is connected to, to be monitored via the speaker in the set.

MAIN MENU #3:
TRANSMISSION TEST
SUBMENU #7: SEND FREQUENCY

Press #7 and ENTER. Next press number corresponding to frequency desired and ENTER. All preset frequencies are sent at 0 dBm.

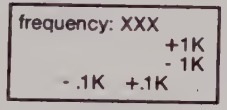


Example: Press #2 and ENTER.

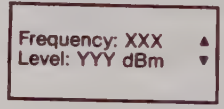
NOTE: Send Frequency defeats the automatic shut-off routine. Make sure the set is manually turned off when testing is finished.

OPTION 7, "Variable" allows the user to select the frequency and level of the transmitted signal from a wider range. Any frequency (at 100Hz increments) between 300Hz and 5kHz can be sent at any level (at 1dB increments) between -10dBm and +5dBm. Instead of typing in the values, the operator is presented with a menu type screen from which he can select the desired values by pressing the appropriate arrow keys.

Example: Press #7 and Enter



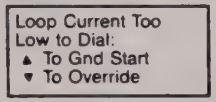
Pressing the appropriate arrow keys (up arrow to increment by 1K, for example) will allow selection of the desired frequency. Pressing ENTER takes us to the next menu.



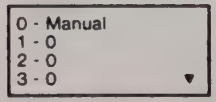
Select the desired level by pressing the appropriate arrow key. When satisfied, press ENTER.

SUBMENU #8: DIAL

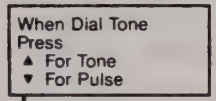
NOTE: Handset should be connected to ring and tip on front panel of RTS and in monitor position.



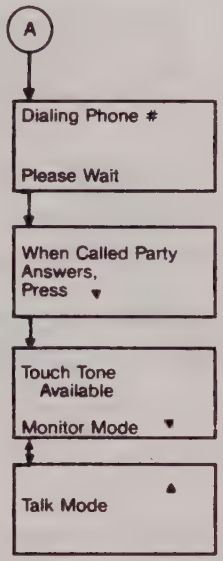
NOTE: This screen appears only if connected to a ground start circuit or a pair that has insufficient loop curcuit.



To obtain programmed number, press its list number and ENTER. For manual dial press 0, ENTER, then phone number and ENTER.



NOTE: Programmed numbers will be displayed. A zero indicates no number has been entered. Up to 9 phone numbers, of 12 digits or less each, can be entered. Press the Down Arrow for additional number entry screens.



Note: Switch handset from monitor to talk.

Often the operator calls the office and is put on hold. Usually, while he is on hold, he can do nothing else since he has to be holding the handset to his ear. The RTS presents a solution to the problem in the following manner:

The operator can dial using the RTS dial function. Once connection is established, the RTS goes into monitor mode. If the operator then presses the down arrow key, the RTS switches to talk mode, connecting Tip and Ring to the front panel terminals of the RTS, allowing the operator to connect his handset to the line through the RTS. The operator's handset must be in the talk mode even during monitor mode. The operator can switch between these two modes as often as he likes for as long as he needs.

NOTE: This function does not "time-out," so it is the operator's responsibility to exit from the dial mode when he is through; otherwise the RTS will stay on until the batteries are drained.

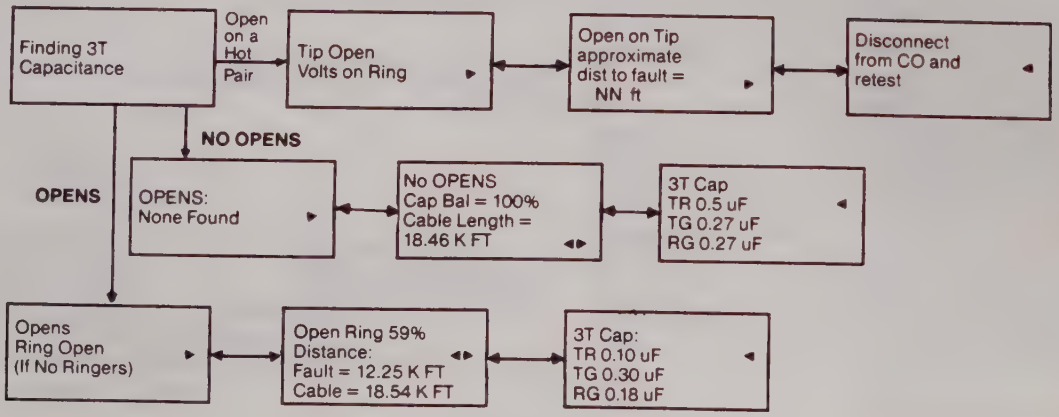
SUBMENU #1: OPEN

From Main Menu press #4 and ENTER to obtain the following submenu listing. The following screen will appear.

```
1 Opens (0)
2 Ohms Fault
3 Distance
4 Loop Current ▼
```

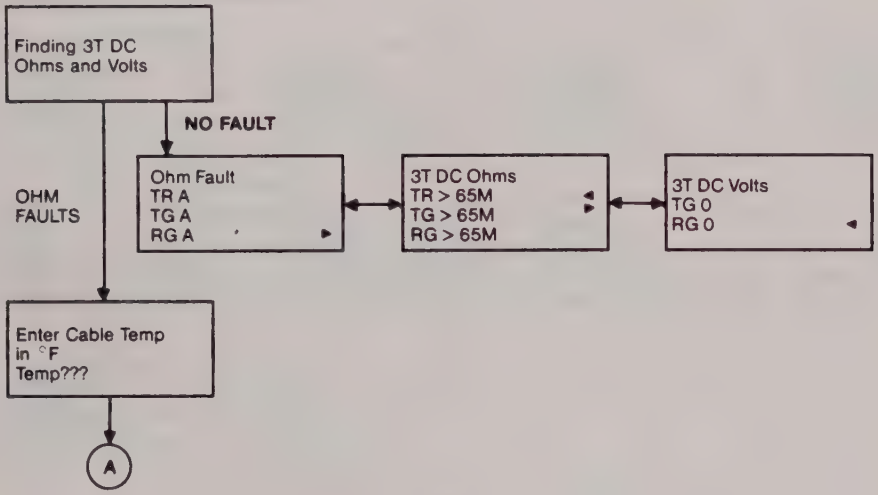
NOTE: Pushing the Down Arrow provides additional menu screens.

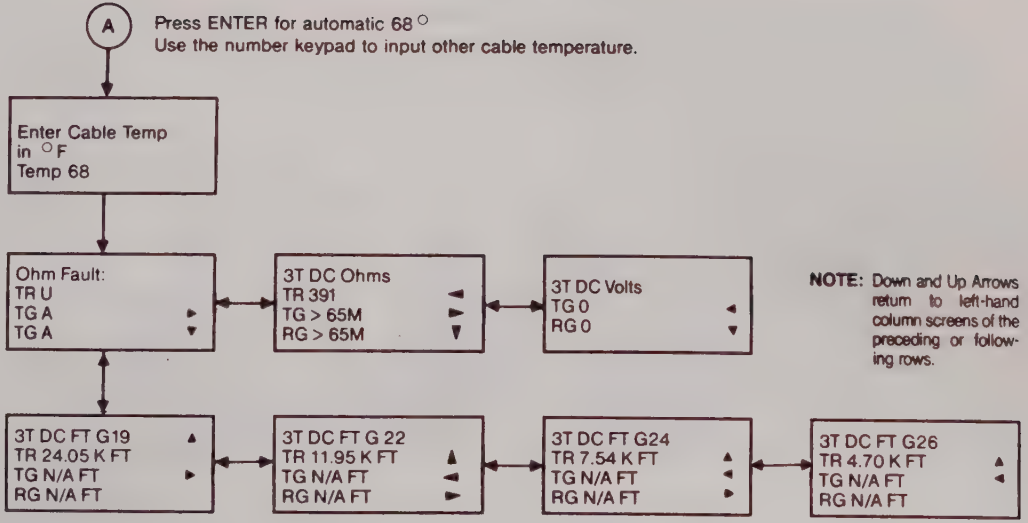
Press #1 and ENTER to select Opens.


Finding 3T Capacitance
Open on a Hot Pair
Tip Open Volts on Ring ▶
Open on Tip approximate dist to fault = NN ft ▶
Disconnect from CO and retest ◀
NO OPENS
OPENS
OPENS: None Found ▶
No OPENS Cap Bal = 100% Cable Length = 18.46 K FT ◀▶
3T Cap TR 0.5 uF TG 0.27 uF RG 0.27 uF ◀
Opens Ring Open (If No Ringers) ▶
Open Ring 59% Distance: Fault = 12.25 K FT Cable = 18.54 K FT ◀▶
3T Cap: TR 0.10 uF TG 0.30 uF RG 0.18 uF ◀

SUBMENU #2: OHM FAULTS

Press #2 and ENTER for Ohm Faults.

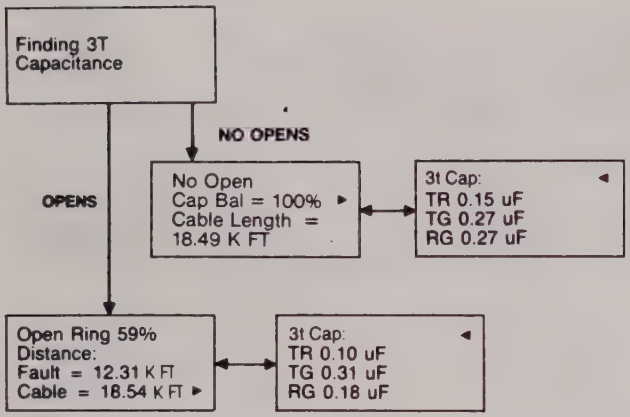



A
Press ENTER for automatic 68 ○
Use the number keypad to input other cable temperature.
Enter Cable Temp
in ○F
Temp 68
Ohm Fault:
TR U
TG A
TG A
3T DC Ohms
TR 391
TG > 65M
RG > 65M
3T DC Volts
TG 0
RG 0
NOTE: Down and Up Arrows return to left-hand column screens of the preceding or following rows.
3T DC FT G19
TR 24.05 K FT
TG N/A FT
RG N/A FT
3T DC FT G 22
TR 11.95 K FT
TG N/A FT
RG N/A FT
3T DC FT G24
TR 7.54 K FT
TG N/A FT
RG N/A FT
3T DC FT G26
TR 4.70 K FT
TG N/A FT
RG N/A FT

MAIN MENU #4: MANUAL TESTS

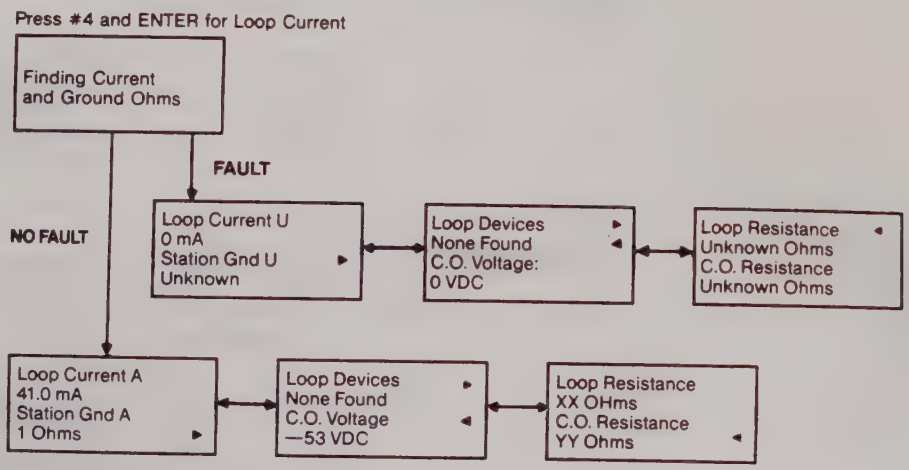
SUBMENU #3: DISTANCE

Press #3 and ENTER for Distance.



MAIN MENU #4: MANUAL TESTS

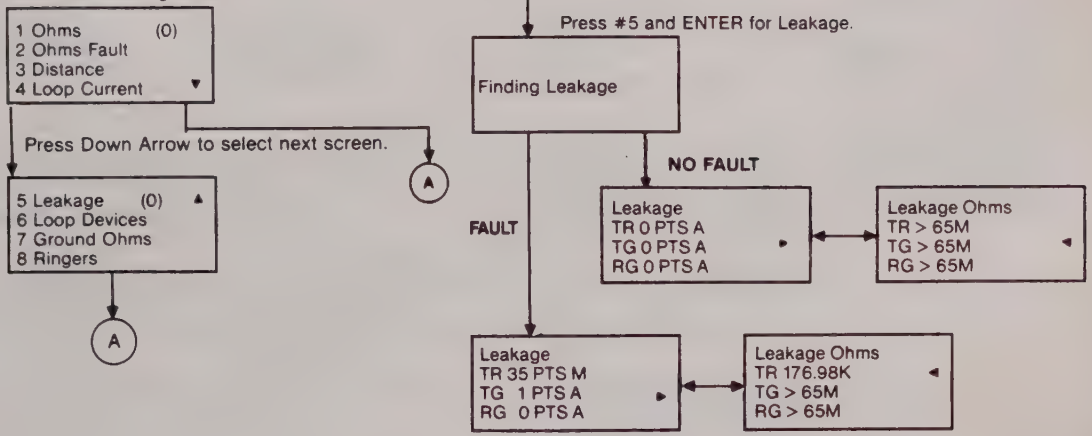
SUBMENU #4: LOOP CURRENT



MAIN MENU #4: MANUAL TESTS

SUBMENU #5: LEAKAGE

From Main Menu press #4 and ENTER to see the following screen.

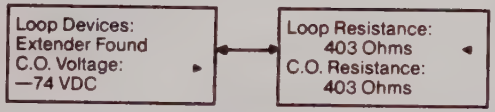


To locate Fault: Use High Resistance Conductor Fault Locator C-4930A.

MAIN MENU #4: MANUAL TESTS

SUBMENU #6: LOOP DEVICES

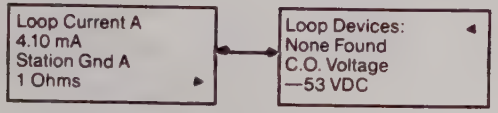
Press #6 and ENTER for Loop Devices.



MAIN MENU #4: MANUAL TESTS

SUBMENU #7: GROUND OHMS

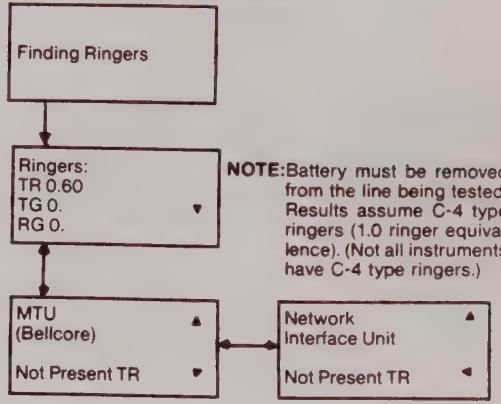
Press #7 and ENTER for ground Ohms.



MAIN MENU #4: MANUAL TESTS

SUBMENU #8: RINGERS

Press #8 and ENTER to find ringers.



NOTE: Battery must be removed from the line being tested. Results assume C-4 type ringers (1.0 ringer equivalence). (Not all instruments have C-4 type ringers.)

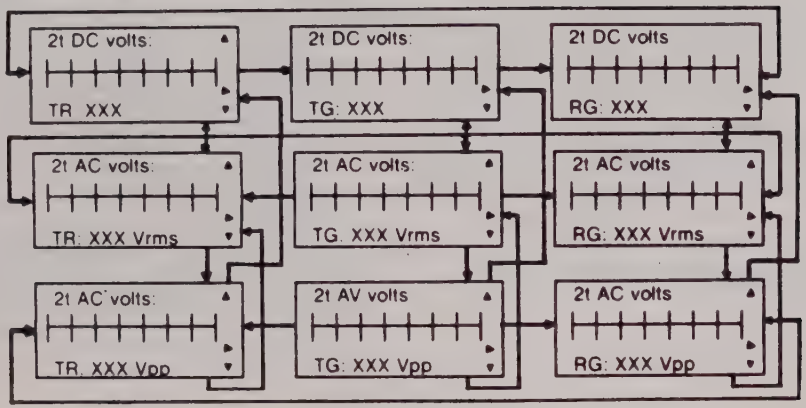
MAIN MENU #5: 2 TERMINAL METER

SUBMENU #1: VOLTS

From Main Menu press #5 and ENTER to see the following screen.

```
1 Volts          (0)
2 Ohms
3 Capacitance
4 dBm/Hz
```

Press #1 and ENTER to select the AC/DC volt meter.



The DC and AC Volt meters have both digital and analog displays. The digital display makes it easy to read the voltage without error. If the voltage is changing, the analog display will allow you to detect the direction and pattern of the change, if there is one. The analog display consists of:

1) A mark which moves left of right as the voltage changes. This corresponds to the needle on a conventional meter.
2) A series of horizontal and vertical marks which correspond to the scale on a conventional meter. These marks are not calibrated on the RTS.

For example, the display would look like this if 25 Volts AC were measured.

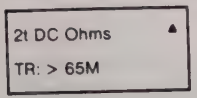
2t AC Volts

TR: 25.0

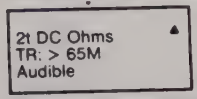
The RTS will make readings for one minute then power down.

SUBMENU #2: OHMS

Press #2 and ENTER to select ohm meter.

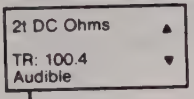


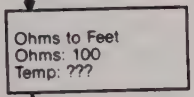
Press Up Arrow for audible.



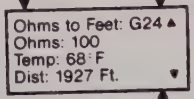
If a resistive fault occurs, the following screen will appear.

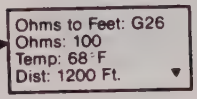
Press Up Arrow for audible

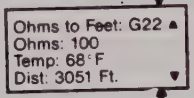


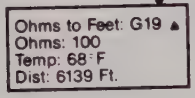


Press ENTER for automatic 68°.
Use the number keypad to input other cable temperature.









The two-terminal Ohm meter repeatedly measures the pair and updates the readings. The Up Arrow on this screen is a toggle to turn an audible tone on and off. Press the Up Arrow and the word "audible" will appear on the screen. In this mode, if the tip-to-ring resistance goes below 10K Ohms, the RTS will sound a signal. (This is particularly useful when waiting for a verification short from the Central Office.) Pressing the Up Arrow again turns the audible command off and the word disappears from the display.

When the measured resistance is less than 10K Ohms, a Down Arrow will appear on the screen. Press it to enter the Ohms-to-Feet routine. When cable temperature is entered, the RTS automatically calculates distance. Use the arrow keys to find the measurement of the gauge being tested.

The RTS will make readings for one minute then power down.

To return to Testing, Press START Twice.

★ Pressing START from Distance screen will return to Temp Screen.

MAIN MENU #5: 2 TERMINAL METER

SUBMENU #3: CAPACITANCE

Press #3 and ENTER to select the capacitance meter.

Press Up Arrow for analog display.

The capacitance meter measures the pair and updates the digital display. There is also an analog display which is especially useful when watching for the capacitance variation or swing of a wet cable. To enable this display, press the Up Arrow. The scale will appear with the pointer at the center. This point is now a reference point at the capacitance measured when the arrow was pressed. As the digital reading is updated, the analog pointer will move to show the percentage between the reference value and the new reading. Any value displayed can be chosen as a new reference by pressing the Up Arrow key, and percentage comparisons will be to this new value.

Each small mark on the analog scale represents 2.5%; each large mark is 10%. The RTS will take readings continuously for one minute then power down. To exit to the menu, press START. A sample display is shown below:

2t capacitance

TR: 12.33 uf

In this example the pointer is one small mark to the right of the center. The present capacitance reading is 2.5% higher than the reference value which was chosen earlier by pressing the Up Arrow key. The present capacitance is 12.33 microfarads.

SUBMENU #4: dBm/Hz METER

Press #4 and ENTER to receive signal and measure loss.

```
dBm/Hz Meter
Level: 0 dBm
Freq: 1004 Hz
```

The dBm/Hz meter measures the level of an AC signal present on a pair, such as the milliwatt tone from the central office, then displays its frequency and level. The RTS continues to measure the signal and update the display. The level is in dBm. Negative numbers indicate that the level is less than the reference value of one milliwatt; positive numbers indicate that the level is greater than the reference value. The frequency of the tone is measured at the same time and displayed. The RTS will accurately measure frequencies between 100 Hz and 10,000 Hz. Noise on the pair normally has no effect on the accuracy of these measurements. The RTS can measure only one tone at a time. If two tones are present at the same time, the RTS measures the combination then displays the results. Since two or more tones can combine in many ways, the results are generally not useful.

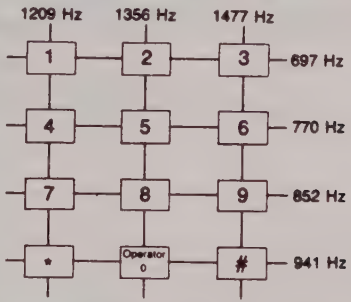
The RTS will make readings for one minute then power down.

TOUCH TONE DIALING CHECK

Use the telephone to be checked. Dial up the quiet termination. This is to prevent operator interference. Connect red and black leads to ring and tip of pair.

To check frequencies, turn on the RTS, press #5 and ENTER, then #4 and ENTER.

On the telephone's touch tone pad press any two numbers in a horizontal or vertical row (see diagram below).

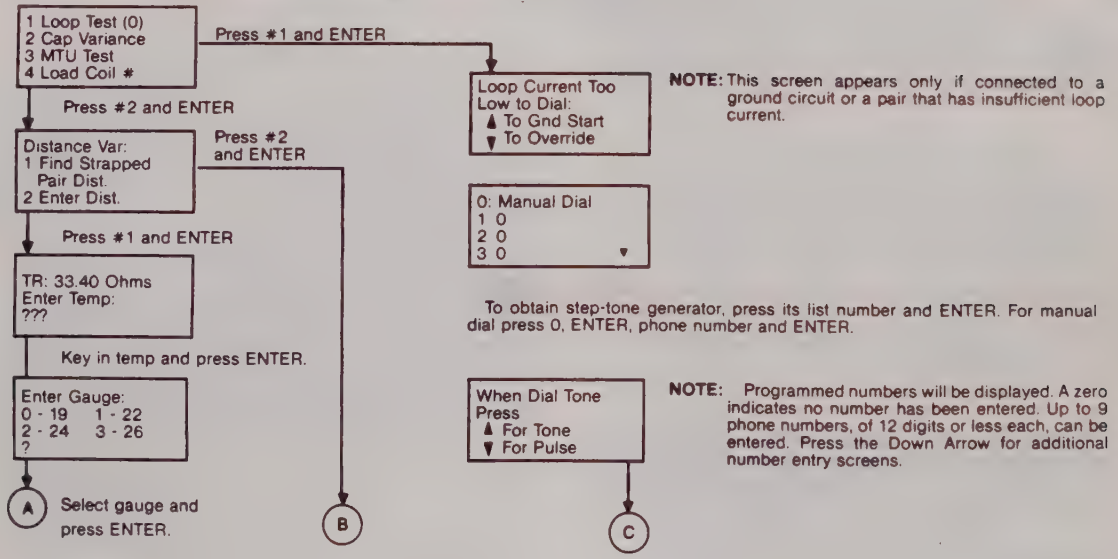


Example: By pressing #1 and 2 simultaneously you should read 697 Hz. By pressing #1 and 4 you should read 1209 Hz and so on. The receiver should register the digit if the frequencies are within ±1.5% of their normal values, but not register the digit if over ±3.5%.

NOTE: Not all telephones work this way!

MAIN MENU #6: CUSTOM TESTS

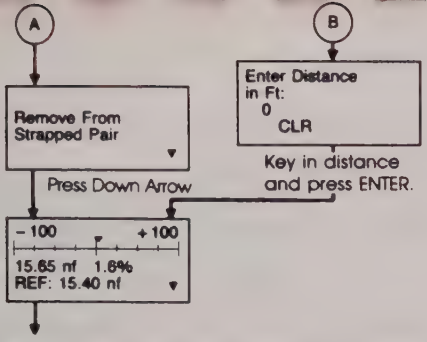
Press #6 and ENTER. The following screen will appear.



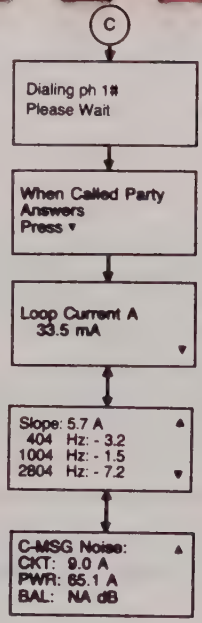
NOTE: This screen appears only if connected to a ground circuit or a pair that has insufficient loop current.

To obtain step-tone generator, press its list number and ENTER. For manual dial press 0, ENTER, phone number and ENTER.

NOTE: Programmed numbers will be displayed. A zero indicates no number has been entered. Up to 9 phone numbers, of 12 digits or less each, can be entered. Press the Down Arrow for additional number entry screens.



Pressing the Down Arrow changes to a higher resolution scale with 0.5% increments from + 10% to – 10% relative to the nearest 10% determined from the low resolution scale.



NOTE: Unit will display gain/slope readings as they are being measured.

MTU TEST

Using the definitions of the MTU Circuit Characteristics as defined in Bellcore Technical Advisory TS-TSY-000324, the RTS is actually able to run an automatic analysis (see algorithm flowchart in Appendix A) of the cable pair that is known to have an MTU to determine the type of fault that is present. The RTS can classify the results as follows:

a. Open - Network

b. Resistive Fault TR (value) - Network

c. Open - Customer

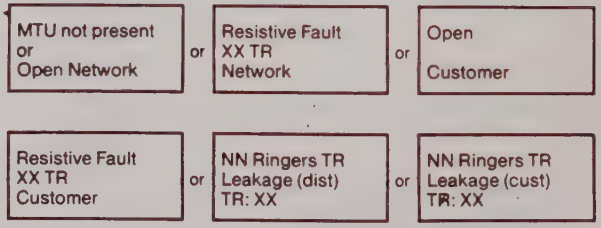
d. Resistive Fault TR (value) - Customer

e. Resistive Fault TR (value) - Distributed

f. Line OK, number of ringers TR: (value)

One limitation of this test is that it cannot tell which side a resistive fault is on if the resistance of that fault is greater than 1 Megohm. In this case, result "e." applies.

In the Custom Menu, press #3 and ENTER.



LOAD COIL COUNT

RTS 2.1D is able to count the number of load coils in series with Tip and Ring on a DEAD cable, with the following limitations:

Maximum number of standard (88mH) load coils: 3 | 5
(3 if 3,000 ft.).

Minimum length of cable extending beyond coil: 3000 ft | 6000 ft
(5 if 6,000 ft.).

In the Custom Menu, press #4 and ENTER.

During testing, a progress screen will appear.

Testing Please Wait XX% complete

After testing, the results are as follows:

Test complete, number of load coils: NN	or	Leads not connected

---

MAIN MENU #6: CUSTOM TESTS

ACCESS SUBMENU #5: (If modem upgrade installed)

SEE SECTION III

MAIN MENU #7: UTILITIES

SUBMENU #1: SEND TONE

Press #7 and ENTER to see the following screen:

```
1 Send Tone      (0)
2 Monitor Line
3 Pair Access
4 Ohms to Feet    ▼
```

Press #1 and ENTER to send tone

```
Send 577.5 Hz
1 Simplex
2 Tip to Gnd
3 Ring to Gnd
```

Precision tone at 577.5 Hz can be sent three ways: sent simplex (Tip-and-Ring to Ground, silent to the subscriber), sent Tip-to-Ground or sent Ring-to-Ground. The send mode (Simplex, Tip-to-Ground or Ring-to-Ground) is chosen by pressing the appropriate number key then ENTER.

```
Send Simplex
577.5 Hz Tone:
 ▲ Constant
 ▼ Alternating
```

Tone can be sent either constant or alternating. The display shows an Up Arrow symbol next to the word "Constant" and a Down Arrow next to "Alternating." Press an arrow to choose the corresponding tone.

When in this mode, the automatic shut-off feature is defeated and tone will be sent as long as the batteries last

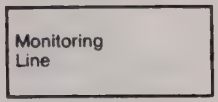
SEND TONE MUST BE TURNED OFF MANUALLY

Press START to turn off Send Tone.

MAIN MENU #7: UTILITIES

SUBMENU #2: MONITOR LINE

Press #2 and ENTER to monitor line.



Allows line to be monitored over the built-in speaker for hands-free operation.

MAIN MENU #7: UTILITIES

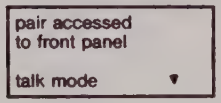
SUBMENU #3: PAIR ACCESS

Often the operator calls the office and is put on hold. Usually, while he is on hold, he can do nothing else since he has to be holding the handset to his ear. The RTS presents a solution to the problem in the following manner:

The operator can select pair access then dial using his handset (butt-in). The screen will remind the operator that he is in talk mode. If the operator now presses the down arrow key, the RTS switches to monitor mode. The operator's handset should preferably be in the talk mode even during monitor mode. The operator can switch between these two modes as often as he likes for as long as he needs.

NOTE: This function does not "time-out," so it is the operator's responsibility to exit from the pair access mode when he is through; otherwise, the RTS will stay on until the batteries are drained.

The following screens appear:



MAIN MENU #7: UTILITIES

SUBMENU #4: OHMS DISTANCE

Press #4 and ENTER for Ohms to Distance conversion.

```
Ohms to Distance
Ohms: ???
```

ENTER Ohms by means of the touch pad numbers then press ENTER. i.e., 38 Ohms

```
Ohms to Distance
Ohms: 38
Temp: ???
```

ENTER temperature in the same manner as Ohms: i.e., 68 ° F.

```
Ohms to Distance    ▲
Ohms: 38      G24
Temp: 68 ° F
Dist: 732 FT        ▼
```

Up Arrow 26 gauge, Down Arrow 22 gauge, Down Arrow again 19 gauge.

MAIN MENU #7: UTILITIES

SUBMENU #5: LIMITS

From Main Menu press #7 and ENTER to see the following screen.

```
1  Send Tone      (0)
2  Monitor Line
3  Pair Access
4  Ohms to Feet
```

Press Down Arrow to select next screen.

```
5  Limits         (0)   ▲
6  Store Ph #
7  Dial
8  Print               ▼
```

press #5 and ENTER for limits.

NOTE: Limits cannot be displayed on the screen, but must be printed. See Submenu #8 for printer hook up and operation.

```
When the Printer
is Connected
Press ENTER.
```

Press ENTER

```
Printing Limits
```

(See following page:)

MAIN MENU #7: UTILITIES

Repair Test Set Limits:

U = Unacceptable M = Marginal A = Acceptable

Loop current (mA):
U < 20.
M < 23.
A > 23.

Station gnd (ohm):
A < 25.
M < 27.
U > 27.

CKT loss (dBm):
A < 8.5
M < 10.
U > 10.

Gain/Slope (dB):
A < 7.5
U > 7.5

CKT noise (dBrnC)
A < 20.
M < 30.
U > 30.

PWR INFL (dBrnC)
A < 80.
M < 90.
U > 90.

Balance (dB):
U < 50.
M < 60.
A > 60.

Leakage (points):
A < 12.
M < 50.
U > 50.

Hazardous DC (Vdc):
A < 120.
M < 130.
U > 130.

Hazardous AC (Vrms):
A < 45.
M < 50.
U > 50.

Tip to ring resistance (ohm):
U < 80.K
A > 80.K

Tip or ring to gnd resistance (ohm);
U < 40.K
A > 40.K

These unacceptable and marginal parameters are programmed at the factory and cannot be changed in the field.

SUBMENU #8 STORE PH

Press #6 and ENTER to store phone #

```
Store Ph #
1 0
2 0
3 0                ▼
```

Up to nine phone numbers, with a maximum of twelve digits each, may be stored for automatic dialing. Currently stored numbers will be displayed. To change or enter a new number:

Press the appropriate list number (1 to 9), then ENTER.

Enter the digits of the phone number to be stored. T1 enters ✱ and T2 enters # where necessary. Press ENTER.

✱ The new phone number is now displayed and is ready for use.

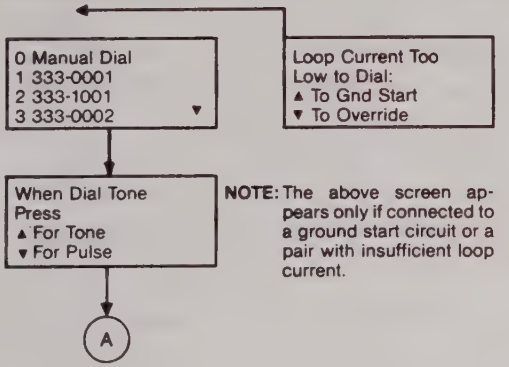
```
Store Ph #
1:213 473 5024
2:0
3:0                ▼
```

Example

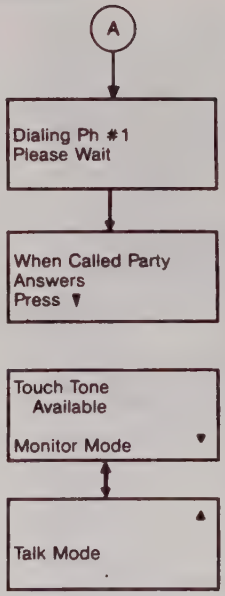
SUBMENU #7: DIAL

NOTE: Handset should be connected to ring and tip on front panel of RTS and in monitor position.

press #7 and ENTER to dial.



NOTE: The above screen appears only if connected to a ground start circuit or a pair with insufficient loop current.



Often the operator calls the office and is put on hold. Usually while he is on hold, he can do nothing else since he has to be holding the handset to his ear. The RTS presents a solution to the problem in the following manner:

The operator can dial using the RTS dial function. Once connection is established, the RTS goes into monitor mode. If the operator then presses the down arrow key, the RTS switches to talk mode, connecting Tip and Ring to the front panel terminals of the RTS, allowing the operator to connect his handset to the line through the RTS. The operator's handset must be in the talk mode even during monitor mode. The operator can switch between these two modes as often as he likes for as long as he needs.

NOTE: This function does not "time-out," so it is the operator's responsibility to exit from the dial mode when he is through; otherwise the RTS will stay on until the batteries are drained.

SUBMENU #8 PRINT

Note: To print test results currently being displayed on screen without erasing from memory, see T-key section.

PRESS #8 and ENTER to begin a print operation

```
Saved Data
(3 data Saved)
1-Print All
2-Recall Case
```

TO PRINT:

To print all test data which has been saved under Case numbers:

- Press the 1 key to select, "PRINT ALL"
- Press the ENTER key.

```
When the Printer
is connected,
Press ENTER
```

- Plug the data transmission cable into the receptacles on the rear of the printer and on the front panel of the RTS.
- Follow directions with your printer to enable it to print.
- Press ENTER to begin printing.

All Case numbers currently in memory and the data saved under them will be printed. After the data has been sent to the printer the data is erased from memory in the RTS. Be sure the printer is ready to receive and print the data before you send it.

The RTS can print test data while it is being displayed or it can print data stored earlier under a case number. Stored data can also be recalled and displayed on the LCD. General instructions for the operation of the printer are contained in the manual which accompanies the printer. Instructions for its operation with the RTS are as follows:

Note: Be sure that the rechargeable batteries in the printer are adequately charged before you begin; or use the AC power adapter/charger. See the Printer Manual for detailed instructions on charging the printer batteries and on other Printer operations.

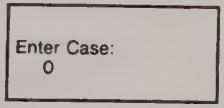
If using the C-9915 printer:

- Set the printer's MODE switch to the center position.
- Press and hold both the PRINT switch and the PAPER ADVANCE switch on the printer while you turn on the POWER switch. This turns on and initializes the printer.
- Press the PAPER ADVANCE switch to move the paper up if necessary.
- The printer is ready for printing.

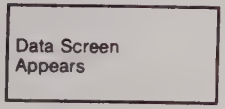
TO REVIEW STORED DATA (RECALL CASE):

To recall test data that has been saved under Case number:

- Press the 2 key to select
- Press the ENTER key to select the following screen.



- Enter Case number digits:
- Press the ENTER key.



NOTE: If arrows appear in the screen, these indicate additional data stored against the same case number.

Hint: To be sure the printer is connected and operating correctly before you print stored data, print a test screen using the T4 PRINT key. To stop printing and retain all screens in memory, Press START.

SUBMENU #9 PROGRAM KEYS

```
 9 Pgm Keys (0) ▲
10 Calculator
11 Clock
12 Case
```

Press 9 and ENTER. The following screen showing the present programming will be displayed.

```
T1 = Clock
T2 = Calculator
T3 = Case
T4 = Print
```

Programming the T-keys:

The four T-keys can be programmed to directly start any Submenu tests or routines. This feature eliminates the need to page through menu screens for frequently used tests and routines. To program the T-keys:

- Press the T-key which you wish to reprogram. A question mark will be displayed after the corresponding T-key display.
- Press the appropriate number key to select a menu from the Main Menu.
- Press ENTER. The question mark will appear to the right of the previous number choice.
- Press the appropriate number key to select a test or routine from the chosen sub-menu.
- Press ENTER. The display will now show the name of the test or routine chosen. The T-key is now programmed.
- To program another T-key press the T-key you wish to change and repeat the above programming steps.

For example: To program the T_1 key to test for Opens:

- Select Program Keys from the Utilities Menu.
- Press the T_1 key.
- Press 4 then press Enter to select the Manual test menu (the menu will not be displayed).
- Press 1 then press ENTER to select Opens from the Manual test menu. The LCD will now show, "T_1 = Opens." The T_1 key is now programmed for Opens.

(continued)

Hint: Use the printed menu inside the cover of the RTS for reference when programming the T-keys. It is arranged so that each Main Menu selection has its entire Submenu listed with it.

USING THE T-KEYS:

The T-keys have five functions.

1. When programmed they select tests and routines directly from the main menu without the need to go through the submenus.
2. T3 is used to save data.
3. T4 is used to print data.
4. They are used with the Calculator.
5. They are used to dial * and #.

To do a program test or routine:

From the Main Menu press the T-key that is programmed for the desired test or routine. The RTS will go to that test or routine directly and return to the main menu when the test is complete.

To print contents of screen:

- Press Key T4 PRINT.

The printer will print all data from the test currently displayed on the LCD. The Case Number, date and time of testing will also be printed. If no Case Number has been entered the printer will print, "Case: 0000000." The data on the LCD will continue to be displayed. If you wish to keep it in memory for later printing you must store it by using the SAVE key (T3).

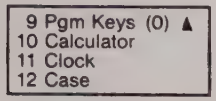
To store data for printing a case number must first be entered. See main menu #7, submenu #12.

To save contents of screen:

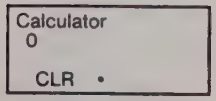
- If a test has been made and the results are displayed on the screen.
- Press the T3 SAVE key. If an audible beep is heard and the display remains unchanged the data has been stored. Proceed to the next test. If instead the screen display changes to the Case Entry format this means a Case Number is required.
- Pressing T3 SAVE a second time saves all data screens at once.

NOTE: A total of 50 screens may be stored in the RTS, any number of screens per case number up to the limit of 15 case numbers.

SUBMENU #10 CALCULATOR



Press #10 and ENTER.



The RTS has a four-function calculator for making mathematical computations. The Calculator display is as above. Note that the "CLR" (for clear) is above the left arrow key. This will clear or erase the current entry. A decimal point " • " appears above the right arrow key. Use this key to enter decimals. The T-keys select mathematical functions: T1 selects add; T2 selects subtract; T3 selects multiply; T4 selects divide. Press ENTER to perform the calculations and display the result.

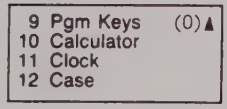
For example:

To add 256.5 to 1300 - Select 10 Calculator from the Utilities Menu.

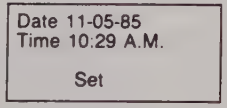
- Press keys 2, 5 and 6, one at a time.
- Press the right arrow key for the decimal point.
- Press key 5.
- Press the T1 key to add.
- Press keys 1, 3, 0, and 0, again. Check that all the numbers displayed are correct. The numbers will not be aligned in columns the way you would put them for manually adding them. If an error has been made press the left arrow key to clear (erase) and start again.
- Press ENTER. The complete problem together with the correct answer will now be displayed on the LCD.
- Press the left arrow key to clear this problem from the display and start a new one.
- The calculator can be used for continuing calculations but each calculation must be completed before another can be entered.

If the RTS is requested to perform a calculation it cannot handle (division by zero, for example), it displays "N/A" (Not Applicable) on the screen.

SUBMENU #11: CLOCK



Press #11 and ENTER for clock.



When selected, the date and time of day are displayed. This information is used when any data is printed using the accessory printer. The LCD will display the date on the first line in the form: Month/Day/Year. The time is displayed on the next line. On the bottom line of the display is the word "set." If you want to change the date and/or set the clock, press the left arrow key which is directly below the word "set." The first two digits of the date will be replaced by question marks. Press the appropriate number keys for the month then press the ENTER key. The first two digits will then show the month and the next two digits will be replaced by question marks. Each press of the ENTER key, after number keys have been pressed, moves to the next two digits until the entire display is correct. AM or PM is chosen with the Left or Right Arrow keys. The clock will start when the ENTER key is pressed.

SUB MENU #12: CASE

```
 9 Pgm Keys      (0)
10 Calculator
11 Clock
12 Case
```

Press #12 and ENTER.

```
Enter Case:

Now - 0000000
New - 0
```

If you wish to store any of the data collected in tests for printing later, a Case number must be stored first. The Case number is the Work Order number or any other number that identifies the job. The RTS will accept up to seven digits. If the work order number is longer than seven digits, use its last seven digits. The LCD will display the current Case number and ask for the new Case number. Press the appropriate number keys, then press ENTER. Any data you store will be kept with this Case number. When you print the data, the Case number will be printed with it to identify where the data came from originally. After entering the current Case number, press START to return to the menu.

Data from any test except Self Test or 2 Terminal Meter tests may be stored for later printing. The Case number must be entered before any data is to be stored. A total of 50 test result screens may be stored under a maximum of fifteen different Case numbers. It is not necessary to enter the Case number again before each test.

Once a test has been performed and the results are presented on the screen, the steps for storing that screen for later printing are as follows:

- Press the T_3 SAVE key. If an audible beep is heard and the screen remains unchanged, the data on that screen has been stored. Pressing the T_3 key again while on the same screen will store all the data screens related to the test that was performed. Three audible beeps indicate that all screens were successfully saved. Once data from a screen is stored, that same screen cannot be stored again; proceed to the next test.
- If no Case number was defined previously, the RTS will automatically display the Case entry screen when the T_3 SAVE key is pressed. Key in a Case number then press ENTER. An audible beep indicates that a new Case number has been recorded. Press the START key. This will restore the results of the test to the display. Proceed with storing the test results by pressing the T_3 SAVE key.

- Once 50 data screens have been stored, any further attempt at storing test data will result in a "NO ROOM FOR ANY MORE DATA!" message. The only way to make room for new data is to print all the previously saved ones.
- Inquiry concerning the number of data screens stored can be made by selecting the Print function (Main Menu #7, sub menu #8) which results in the following display (where XX is the number of screens saved).
- A new case number must be stored for each new trouble ticket; otherwise, all data will be stored to the original case number.

```
SAVED DATA
(XX data saved)
1 Print all
2 Recall case
```

Batteries

The RTS uses six standard C-size cells to power its circuits. Alkaline cells are recommended. Nickel-cadmium rechargeable cells are also recommended. Carbon-zinc cells may be used but are not recommended due to their short life and poor temperature characteristics. It is recommended that all six cells be of the same type; do not mix battery types.

If Self Test is done, the RTS will give message, "LOW BATTERY" when the voltage falls below an acceptable level and the display will flash on and off. The display that is on the screen in any other mode will also flash on and off when batteries are in a low condition. Change all six cells. The RTS uses them all equally.

The RTS uses a tiny amount of battery power, even when it is turned off, to maintain the information stored (phone numbers, T-key programming, clock/date) and data you have saved. Even when the batteries are nearly exhausted there is adequate power to do this. When the batteries are removed a built-in keep-alive circuit will supply power to the memory for at least five minutes. After this time the contents of memory may be lost. The programming from the factory such as menus and tests is permanent and will be retained regardless of battery power.

NOTE: Alkaline batteries will show low at 6.2 volts; NiCad will show low at 6.8 volts.

Changing batteries:

- Check that the RTS is turned OFF.
- Close the cover and turn the RTS upside-down.
- Remove the battery access plate on the bottom of the test set by unscrewing the two captive screws which secure it.
- Remove the old batteries from the battery holder. Insert fresh batteries into the battery holder observing correct polarity.
- Check the battery access plate and gasket for debris or damage that could prevent making the watertight seal and correct any problems found.
- Put the battery access plate in place and tighten the two screws. Use care so that the battery holder connecting wires are out of the way.
- Avoid excessive tightening; the gasket can only seal if the plate and case are free of distortion.
- As a final check, turn the RTS ON and do Self Test. Set the RTS for the type of battery in use (Alkaline or Nickel-cadmium).

Cleaning

CAUTION: Do not use chemical base cleaners on front panel.

Repairs:

Initialization:

When the battery has been removed, or power has been interrupted for some other reason for an extended period, the RTS may need to be re-initialized. Incorrect displays, parts of displays absent, T-key programming problems, or disrupted stored phone numbers are indications that the test set needs initialization.

Initialize the RTS:

- From the Main Menu press keys nine then eight so that ninety-eight is displayed in parentheses (98).
- Press ENTER. The RTS will reset all its mechanical relays, erase all stored data and initialize itself.

If the RTS should malfunction or be damaged it should be returned to the factory or to an authorized repair station. There are no fuses or user serviceable parts inside.

DO NOT OPEN THE TEST SET!

Some of the circuitry is sensitive to static electricity and will be seriously degraded or destroyed unless handled with special precautions.

Lock-Up:

Under certain conditions the RTS will fail to respond to the keyboard.

To unlock the test set:

- Disconnect the test leads from the pair.
- Close the cover and turn the test set upside down.
- Using a screwdriver remove the battery compartment cover.
- Remove one battery from the test set.
- After 15 seconds have passed, reinstall the battery.

ABBREVIATIONS AND SYMBOLS

A	Acceptable Limits
CKT	Circuit
dB	Decibels
dBm	Decibels above or below 1 mWatt
dBmC	Decibels reference noise C-weighting
Dist	Distance
G	Gauge. For example: G22 means "22 - gauge wire."
Gnd	Ground
Hz	Hertz (cycles per second)
K	One Thousand
Kft	Thousand feet
LCD	Liquid Crystal Display
M	Marginal Limits
mA	Milliamps (electric current)
N/A	Not applicable
NaN	Not a Number
nF	Nanofarads 1000 nf = 1 uf
Nm	Noise metallic (circuit noise)
Ng	Noise to ground (power influence)
Ph#	Phone Number
pf	Picofarads 1000 pf -1 nf
RTS	Repair Test Set
Temp	Temperature
uf	Microfarads 1000 nf =1 uf
Vpp	Volts measured peak-to-peak
Vrms	Volts root mean square. Standard AC volts
Vdc	Volts direct current
◄	Left arrow
►	Right arrow
▲	Up arrow
▼	Down arrow
(0)	Currently selected choice from menu
<	Less than. For example: 3 < 4
>	Greater than. For example: 7 > 6
2t	Two terminal (conventional) measurement
3t	Three terminal measurement
/	Per. For example: 2/ means "Two per division of the scale" when displayed on an analog meter reading.
#	Number or pound sign
T	Tip or T-keys
R	Ring
TR	Tip-to-Ring
TG	Tip-to-Ground
RG	Ring-to-Ground
S/N	Serial Number
U	Unacceptable Limits

GLOSSARY OF TERMS:

Analog display
A display that represents data by continuously variable physical quantities. For example: as the voltage increases the position of the indicator line on the voltage display moves farther to the right. The position of the indicator line is analogous to the voltage.

Balance
A measure of how near to equal the Tip and Ring are in carrying Power influence. If they are exactly equal Power influence produces no Circuit Noise (audible to the customer). It is measured in dB. A well balanced pair will have 60 dB balance or more.

C-message weighting
A filter is used to change the frequency response of a meter so that the measurement is made similar to the way the human ear would respond.

Capacitance
A measure of the amount of charge a capacitor will hold. Usually measured in microfarads, nanofarads or picofarads. One microfarad = 1000 nanofarads = 1,000,000 picofarods.

Case Number
A number used to identify the job or case of trouble. This may be taken from the work order or some other source.

Circuit Noise
The noise measured across Tip and Ring measured in dBrnC. This is audible to the customer. Also called Noise Metallic.

Decibel (dB)
A measured unit which compares the ratio of one signal to another signal. The signal may be a voltage, current, sound pressure or particle velocity. Frequently the signal is compared to a standard signal strength.

dBm
Decibels above or below 1 mWatt. Decibel measurement unit where the standard signal strength is one milliwatt.

dBrnC
Decibel measurement unit where the standard signal strength is 90dB less than the one milliwatt standard noise signal. The measurement is also C-message weighted.

Digital display
Numbers (digits) that are shown on a screen (display) which represent the results of a test.

Ground Ohms
The resistance of the ground path to the Central Office.

Liquid Crystal Display (LCD)
A type of display which electrically changes a crystal structure to control how light reflects from it. Unlike Light Emitting Diodes (LEDs) or Neon displays, Liquid Crystal Displays produce no light of their own and are easy to read in bright light.

Loop Aid
Extender. A device put on a pair to increase the loop current to an acceptable value.

Loop current
The electric current that will flow through a 430 ohm resistor if it is connected to Tip and Ring.

Loss
A comparative measurement of how much signal is lost in traveling from the Central Office to the measurement location.

Main Menu
The first and most general menu from which choices are made.

Menu
A list of options to choose from.

Microprocessor
A microelectronic chip containing logic circuitry used as the central working element of a computer.

Noise Metallic (Nm)
The same as Circuit Noise.

Points
A measurement unit used in the telephone industry for leakage measurements. Points can also be expressed in ohms.

Power Influence (Ng)
A measurement of the induced power on a pair measured from Tip and Ring (tied together) to Ground. Measured in dBrnC. Power influence would not be audible to the customer if pairs were perfectly balanced. When a pair is unbalanced Power influence results in Circuit Noise which is audible to the customer.

Ringer
The mechanism that rings the bell in a standard Western Electric 500 telephone set. Other telephones may have a ringer which is equal to some other value (such as 1.2 or .9 for example).

Simplex
When tone or any other signal is sent over both Tip and Ring equally to Ground this is called simplex. The tone is inaudible to the customer if this is properly done and pair is well balanced.

Slope

A measurement in dB of the frequency response of a pair. It is made by comparing the transmission of signals at 404 Hz, 1004 Hz, and 2804 Hz.

Submenu

A secondary menu. When there is more than one option on the choice made from the Main Menu a Submenu is displayed.

T-keys

User definable function keys. Four programmable keys which can be used to directly select any of the tests or routines the RTS can perform which are reached from Submenus.

Three-terminal measurement

Measurements made in a special way so that they can be converted to Thevenin equivalent circuit model values. Three-terminal measurements and the 3-terminal values that are derived from them are fundamentally different from conventional 2-terminal measurements. Three-terminal values and 2-terminal test results are not directly comparable since they make their measurements differently. Some conventional measurements use three test leads but this does not result in 3-terminal measurements. Many Central Offices use Automatic Loop Testing equipment which uses 3-terminal measurements.

Two-terminal measurement

Conventional measurement of electrical circuits. Two terminal measurements may use three or more test leads in some cases but are measuring in conventional ways so they are still called 2-terminal measurements in the Repair Test Set.

Three-terminal and two-terminal measurement.

The RTS makes measurements in two different ways. It makes 2-terminal measurements the same as other test sets such as voltmeters, ohmmeters, and ammeters. It displays the results of these tests in digital form (numbers) and in some cases in analog (a pointer on a scale) form also. The readings are in volts, ohms, or milliamps. These are all familiar to most people in repair.

The RTS also makes 3-terminal measurements which are different from what any portable test set could do in the past. The Mechanized Loop Test (MLT) equipment in the Central Office, or its equivalent by another name, uses 3-terminal test procedures. The MLT values which the Repair Service Bureau may send out will be 3-terminal values.

The test procedure used to get these values is quite different from 2-terminal values. What the MLT and the RTS do is measure various combinations of Tip-to-Ring. Tip-to-Ground, and Ring-to-Ground while shorting another combination

or injecting current into the pair for example. The results of the measurements are then used in some complex mathematical calculations which result in the 3-terminal values which are displayed on the screen of the test set. These results are called values because they actually represent the value of a battery voltage or a resistor that would be required if you wanted to construct a circuit that would act exactly like the pair. There are two circuits called the Thevenin-equivalent Circuits which are used as standards for 3-terminal DC and AC measurements.

Two-terminal measurements simply measure whatever is on the pair while interfering as little as possible. The two measuring systems are fundamentally different and the results should be treated as different tests just as temperature and humidity are different.

Which is better, 2-terminal tests or 3-terminal tests? Neither is better; each has advantages. The RTS makes both available. When you want to compare the readings you get on a pair to the MLT, you must measure the same way the MLT made its measurement. In most cases the C.O. makes 3-terminal measurements. When you want to compare readings with conventional meter readings use 2-terminal measurements. When you want to diagnose a case of trouble you can use both.

Warning, Code or Error Messages

There are five warning, code or error messages the RTS can display:

1. Data overflow (value too high).
2. Most significant A/D status byte not ready.
3. Least significant A/D status byte not ready.
4. Excessive current.
5. Low battery voltage-test results may be incorrect.

SPECIFICATIONS

Physical Specifications:

Dimensions:	Height = 11″ Length = 10.5″ Width = 5.2″
Weight:	8.7 lb. with batteries
Sealing:	Test set water and dust resistant. Submersion in water should be avoided however.
Switches:	Monopanel front panel with membrane type switches.
Storage temperature:	-40 °F to +120 °F (-40 °C to +50 °C)
Operating temperature:	0 °F to +120 °F (-18 °C to +50 °C)
Humidity	90% non condensing

Electrical Specifications:

Power supply:	6 C-size batteries
Recommended batteries:	Alkaline cells or Nickel-cadmium rechargeable cells.

All functions are auto ranging.

Electrical tests unit performs on cable pair:

- AC Voltage: 0 to 400 VAC (± 2% ± .5V)
- DC Voltage: 0 to + 400 VDC (± 2% ± .5V)
- DC Current: 0 to 200mA DC
  (± 1% ± .3mA)
  (at 20mA ± .3mA)
  Zin = 430 Ohms
- Resistance: 0 to 65 Megohms
  0 - 200 ohms (± 1% ± 2 ohms)
  200 - 1 Megohm (± 1%)
  1M - 3.5 Megohms (± 2%)
  3.5 - 65 Megohms (± 10%)
- Capacitance: 10 pf to 5 uf (± 2%)
- Loss: -40 to +10 dBm (± 0.5 dBm)
  (Freq. 100 Hz to 10 KHz ±5Hz)
  Zin = 600 ohms
- Metallic Noise: 0 to 50 dBmC (± 0.5 dBmC)
  Zin = 600 Ohms
- Power influence: 40 to 100 dBmC (± 0.5 dBmC)
  Zin + 100K Ohms

- Distance: 0 - 100 ft. (± 1% ± 4 ft.)
  100 - 20,000 ft. (± 1% ± 10 ft.)
  20,000 - 200,000 ft. (± 3%)
- Leakage : 0 to 100 points (± 1 point)
- Ringer Count: 0 to 5 C-4 type ringers (± .5)

Outputs:

- Tracing tone: 577.5 Hz continuous or alternating
- Send Frequency: 404, 1004, 2713, 2804 3000, 5000 Hz at 0 dBm ± 0.5 dB Zout = 600 ohms

Variable Frequency Send Option Specifications:

- Minimum Frequency Transmitted: 300 Hz
- Maximum Frequency Transmitted: 5000 Hz
- Transmit Frequency Tolerance: ± 1%
- Minimum Level Transmitted: -10 dBm
- Maximum Level Transmitted: +5 dBm
- Transmit Level Tolerance: ± 0.5 dB

- Dial - Standard pulse or standard DTMF

- Printer: Connector

- Terminals on front panel to access pair under test.

Miscellaneous Functions:

- Self Test
- Line Monitor
- Automatic calculation of line balance
- Identifies pots pairs
- Detects and identifies loop aids (extenders)
- Indicates if Loop Current is within acceptable limits
- Indicates if Circuit Loss is within acceptable limits
- Indicates if Gain/Slope is within acceptable limits
- Indicates if Ground Ohms are within acceptable limits
- Manual dialing
- Automatic dialing of stored phone numbers
- Tests for Opens
- Tests for Resistive Faults
- Automatic distance calculation using capacitance or resistance
- Indicates if Leakage is within acceptable limits
- Makes measurements by conventional 2-terminal methods or by 3-terminal Thevenin method.
- Four-function calculator
- Clock with date and time of day
- Case or job number recording for either current or later print-ou
- Measures gain slope 3 frequencies up to 11 frequencies

C-9925A P/N 1842401

REPAIR TEST SET

Section III: ACCESS SYSTEM

COMMUNICATIONS TECHNOLOGY CORPORATION

DALLAS, TEXAS • (214) 991-8338

C-9925A
ACCESS SYSTEM

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SECTION III - A: INTRODUCTION

1.1 INTRODUCTION

This document is intended to describe the new functions that the Repair Test Set Craft Access Model provides. This document consists of two sections as outlined below:

SECTION 1 - Introdution.
Contains a brief list of the functions this model entails.

SECTION 2 - Operator's Guide
Provides instructions on using the new features and functions of the Craft Access Model.

1.2 FEATURE LIST

1.2.1 NETWORK ACCESS - Access is gained from the custom menu. When the RTS is turned on, it checks to see whether the internal modem is present. If no modem is present, the access is not offered.

1.2.2 VOICE - One of the requirements of craft access is the provision by the field terminal for voice access. This RTS routine works exactly like the DIAL function, offering monitor or talk mode, and touch tone transmission while on-line.

1.2.3 MODEM - The main features of access are based on the ability of the field terminal (RTS) to communicate through a modem. Any combination of communications parameters can be selected by the user (300/1200 BAUD). When initialized, the RTS defaults to the specified parameters of 1200 BAUD, 7 data bits, 1 stop bit and even parity.

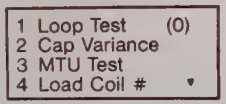
1.2.4 The ability to download, store, and print a file is also a must for a field terminal. The RTS provides 30K of battery backed-up RAM for this purpose. This amount of memory can easily hold ten files, which is the maximum the RTS allows at any one time.

1.2.5 The RTS allows selective erasure of any of the files it currently holds.

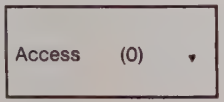
SECTION III-B: Operator's Guide

2.1 THE ACCESS MENU

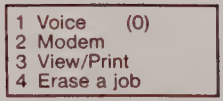
The RTS will only provide ACCESS MENU if there is a modem in the unit (the RTS automatically checks for this). If the RTS does not have an optional modem, the access menu is provided in the Custom menu. Select Main Menu #6.



In the Craft Access Model, a down arrow is shown, suggesting additional features. Pressing the down arrow shows us the access choice.



By pressing 5 and ENTER at this point, we enter the access features.



2.2 VOICE ACCESS

We can gain voice entry to a Craft Access System or Network Access System by selecting option #1 from the Access features menu. The voice access routine works exactly like the DIAL routine (Main Menu #3, Submenu #8 or Main Menu #7, Submenu #7). The RTS will dial out either touch tone or pulse, but once connection is established, it defaults to touch tone to allow communications through the use of the keyboard.

2.3 MODEM

Selecting the Modem option (#2) takes us to another menu.

2.3.1 SET COMMUNICATIONS PARAMETERS

Prior to actually dialing a Craft Access System or Network Access System, we need to set the communications parameters. The specified parameters for access are: 1200 BAUD, 7 data bits, 1 stop bit, EVEN parity. The RTS defaults to these parameters when initialized, so there is no need to set parameters if these are the desired ones. To select any other combination of communications parameters, select option #1.

```
1 Baud: 1200
2 Data: 7
3 Stop: 1
4 Par:  EVEN
```

Pressing the INDEX key corresponding to the desired parameter (1, 2, 3, and 4) will toggle the available options for that parameter. For instance, pressing 1 will result in:

```
1 Baud: 300
2 Data: 7
3 Stop: 1
4 Par:  EVEN
```

Pressing 1 again will restore the 1200 BAUD option.

```
1 Baud: 1200
2 Data: 7
3 Stop: 1
4 Par:  EVEN
```

Pressing 4 will toggle the parity option.

```
1 Baud: 1200
2 Data: 7
3 Stop: 1
4 Par:  ODD
```

Pressing 4 again . . .

```
1 Baud: 1200
2 Data: 7
3 Stop: 1
4 Par:  NONE
```

And so on . . .

Once a desired set of parameters appears on the screen, press ENTER to store them. To escape (not to save what is on the screen), press START. If START is pressed, the parameters will be reset to what they were before the set option was selected.

2.3.2 DIAL NETWORK

When we are ready to call a Network Access System, we select option #2. We can also access the call routine directly from the RTS Main Menu by pressing 65 and ENTER. The routine begins just as the DIAL routine usually does, taking us through a progression of screens while checking for loop current, requesting phone number and offering a choice between touch tone and pulse dial. The monitor is activated before the RTS goes off hook, allowing its use to abort if the line is busy.

Once the RTS connects to the Network Access System, (Network or System) the system will prompt for login and ID number. These are provided by the craft person's supervision. Once access, if granted, the RTS and the system enter into a prompt response mode of operation as follows:

1. The RTS first goes into receive mode, awaiting input from the system. As the data comes in, the RTS displays it on the screen, scrolling once the screen is full. Due to the small capacity of the RTS display screen, the information is very difficult to read as it is printed. An additional facility was provided for displaying the information once the system transmission is finished. Pressing any key once the system transmission is finished (or even before, if so desired) will set the RTS into transmit mode.

2. In transmit mode, the RTS no longer accepts any input from the system. It allows the user to scroll through the information already received by pressing the down, up and right arrows. Pressing the down arrow scrolls one screenful down. Pressing the up arrow scrolls one screenful up. Pressing the right arrow scrolls each line horizontally. (Each line is set up to hold up to 40 characters, even though only 13 of them can be seen on the screen before scrolling). Pressing the right arrow again will act as a toggle to HALT/CONTINUE the scroll.

In transmit mode the function keys T1, T2, and T3 act like shift keys operating on the numeric keys, providing alphanumeric capability. The new RTS front panel makes this operation obvious. Once an alphanumeric key is pressed, the word "REPLY:" appears on the 4th line of the screen. As the reply is entered, the 4th line will refresh to show the new characters entered. The capacity of the reply buffer is also greater than the capacity of the screen, so once line four is full, the reply display will start scroll right. If an incorrect character was entered, use the left arrow as a backspace key.

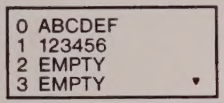
Once ENTER is pressed, the RTS transmits the contents of the reply buffer to the system, then re-enters receive mode.

3. File capture mode. If, at any time during transmit mode the T4 function key is pressed, the RTS enters file capture mode. In this mode the RTS first prompts for a filename. This name should be no longer than six characters. If this filename already exists, the RTS will warn the user of this fact. Once the filename is entered, the RTS transmits the contents of the reply buffer, then goes into receive mode. Whatever the RTS receives next (up to the time when the user presses a key) is stored under the filename specified beforehand. The RTS automatically exits its file capture mode after one transmit/receive cycle.

To disconnect from the system, simply press the START key at any time. NOTE: THE "CALL NETWORK" OPTION IS DIRECTLY ACCESSIBLE FROM THE RTS MAIN MENU BY ENTERING "65."

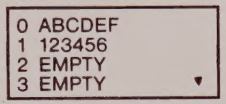
2.3.3 VIEW/PRINT A FILE

Select option #3 from the ACCESS features menu if a file dump to printer is desired. The screen that appears will list the names of the available files (up to 10). Select the appropriate index key to print the desired file.

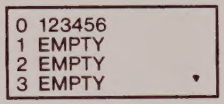


2.3.4 ERASE A FILE

Select option #4 from the ACCESS features menu, if a file is no longer necessary and a file erase is desired. The screen that appears will list the names of the availabe file (up to 10). Select the appropriate index key to erase the desired file.



If 0 is pressed, for instance, file ABCDEF is erased and the filename display is refreshed:



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